IDA PAPER P-3131

THE CAPABILITY OF THE CONSOLIDATED AUTOMATED SUPPORT SYSTEM (CASS) TO MEET EXPANDED TEST REQUIREMENTS

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19960828 056

April 1996

Prepared for
Office of the Deputy Under Secretary of Defense (Logistics)

Approved for public release; distribution unlimited.

INSTITUTE FOR DEFENSE ANALYSES
1801 N. Beauregard Street, Alexandria, Virginia 22311-1772

IDA Log No. H 95-047271

The work was conducted under contract DASW01 94 C 0054 for the Office of the Deputy Under Secretary of Defense. The publication of this IDA document does not indicate endorsement by the Department of Defense, nor should the contents be construed as reflecting the official position of that Agency.

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Contract DASW01 94 C 0054
Task T-AO7-1095

PREFACE

The purpose of this study is to identify options, and estimate the costs of these options, for improving the ability of CASS (Consolidated Automated Support System) to meet broader test needs than those for which it was originally designed. The work was sponsored by the Director, Weapon Support Improvement Group, Office of the Assistant Secretary of Defense (Economic Security). The work supports PMA-260, the Aviation Support Program Office in the Naval Air Systems Command (NAVAIR), the office that manages the CASS program.

This is the second report that the Institute for Defense Analyses has prepared under the task order. The first report (Reference 1) was issued in November 1993. It analyzed CASS performance across the board and proposed a variety of improvements that appeared promising. The current study provides more detailed analysis of CASS performance, both hardware and software.

The hardware analysis focuses on radio frequency (RF) testing, with some additional analysis on related analog and digital requirements. All analysis is carried out by identifying the test requirements of electronic systems found on Navy aircraft and ships, Marine aircraft and ground systems, and Air Force aircraft. These requirements are compared with the current test capability of CASS and improvements are identified to remove any shortfalls. The life-cycle costs of the improvements are estimated.

The software analysis identifies improvements to ensure compatibility between current and new CASS configurations. Other software topics include improving the operation of CASS software in general, and providing a long-term roadmap to move CASS toward a more open software architecture.

This report was reviewed within IDA by Herbert R. Brown and Stanley A. Horowitz.

ACKNOWLEDGMENTS

We received substantial help on the hardware analysis (Part 1 of this study) from people involved in testing at the following installations: Lockheed Martin at Orlando, FL; the Naval Air Warfare Center at Lakehurst, NJ; the Naval Surface Warfare Center at Dahlgren, VA; the Marine Corps Logistics Base at Albany, GA; and the Marine Corps Combat Development Command at Quantico, VA. Additional electronic system performance data were provided by the Electromagnetic Compatibility Analysis Center at Annapolis, MD.

We received substantial support for the software analysis (Part 2 of this study) from people at the following installations: Lockheed Martin at Orlando, FL; the Naval Air Warfare Center at Lakehurst, NJ; the Naval Sea Warfare Center at Crane, IN; and the TPS Integration Facility at Jacksonville, FL. Test Automation Inc., under subcontract to IDA, helped with the estimates of TPS development costs in Task 2.

We thank all these groups for their help.

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BACKGROUND

The Office of Secretary of Defense (OSD) has embarked on a long-term program to reduce the costs of testing electronic equipment. The ultimate goal is to replace the multitude of single-purpose testers that are tailored for individual weapon systems by a few highly capable testers than can each test a wide range of electronic systems. OSD's strategy for reaching this goal is to eliminate investments in automatic test systems that are unique to particular weapon systems and that duplicate capabilities already in DoD.[1] New capability required by new weapons would be obtained, to the extent possible, by expanding the performance of existing, multi-purpose test systems. By cutting down on the number of new systems, we should be able to save on the costs of development, procurement, and logistics support (through reduced range of spares and fewer training syllabi).

Another facet of OSD's strategy is to develop a DoD-standard environment for test that, by permitting greater use of commercial components and software, will reduce the time and cost of developing test programs, and lead to further savings.

As a contribution to this initiative, the Navy developed the Versatile Avionics System Test (VAST) tester 20 years ago, and has developed the Consolidated Automated Support System (CASS) in recent times to test modern, high-technology Navy avionics systems. OSD has since chosen CASS as an initial automatic test system family, because it was found to meet many test requirements, not only of Navy avionics, but also of shipboard electronics and the electronics of the other Services. The Aviation Support

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1 CASS is referred to as an Automatic Test System (ATS). An ATS consists of (a) Automatic Test Equipment (ATE) hardware and operating system software, (b) Test Program Sets (TPSs) that include the hadware connectors and software programs to test individual electronic systems (Units Under Test, or UUTs), and (c) associated software environments used in the development of ATE and TPS software. ATSs are used in DoD intermediate-level and depot-level maintenance facilities to test electronics systems that are difficult or impossible to test manually, to reduce troubleshooting times, and to augment the skills of field technicians. ATSs are also used in manufacturing in-process testing and acceptance testing.

Equipment Program Office in the Naval Air Systems Command (PMA-260; also called the CASS Program Office) asked IDA to analyze how CASS could help fill this expanded role. A previous study (Reference 1) identified some improvements to increase CASS functionality to test Navy avionics. The present report deals more explicitly with hardware and software issues involved in extending the role of CASS in the new directions mentioned above. The study was sponsored by the Director, Industrial Capabilities and Assessment (formerly Weapon Support Improvement Group), Office of the Assistant Secretary of Defense (Economic Security), and was directed to support PMA-260.

The report consists of an introduction containing a brief discussion of the issues, plus detailed analysis in two parts. Part 1 presents the analysis of the hardware testing requirements of the various platforms: Navy aircraft and ships, Marine Corps aircraft and ground systems, and Air Force aircraft. We compared these requirements with the current capability of CASS, noted shortfalls, and identified improvements that would reduce the shortfalls. The 10-year cost of each improvement was estimated by summing the nonrecurring costs of development, integration, and procurement of a nominal 100 units, and adding to that the recurring costs of operating and supporting the improved upgrade for 10 years. (We lacked the resources to estimate the procurement costs based on the actual number of CASS units to be improved.)

Part 2 of the study deals with several issues concerning the software in the CASS station itself, as well as in the Test Program Sets (TPSs) that direct the tests of individual electronic systems. The analysis identified improvements needed to ensure compatibility across proposed new full-size and downsize CASS configurations. We also discussed ways of improving the general operation of CASS software and provided a long-term roadmap of changes to move CASS toward a more open architecture.

Appendices to the paper are related to Part 1. Appendix A presents the data on which the analysis in Part 1 is based, and Appendix B describes the cost model. Appendix C presents a brief analysis of the possibilities for developing downsize CASS configurations for use on Navy ships that are smaller than aircraft carriers and large amphibious ships, and for deployment with Marine Corps ground forces.

SUMMARY OF ANALYSIS

Part 1. Hardware Analysis

Test requirements of Navy, Marine, and Air Force electronic systems were obtained from two main sources:

1. The System Synthesis Model (SSM) containing the characteristics of electronics systems for Navy aircraft, Navy ships, and Marine Corps aircraft, which is maintained by the Naval Air Warfare Center at Lakehurst, New Jersey.
2. The database of operating frequency and other electrical characteristics of electronic equipment used by all the Services, which is maintained by the Air Force's Electromagnetic Compatibility Analysis Center (ECAC) located in Annapolis, MD.

To increase the coverage of the SSM data for the present analysis, the IDA study group inserted data for an additional 20 systems: 6 Navy ship systems, 8 Marine Corps aircraft systems, and 6 Marine Corps ground systems. The final SSM database used by the study consists of 99 electronics programs representing 1,232 Units Under Test (UUTs). (The SSM lists data for electronics "programs." A program could be a system such as an F/A-18 C/D radar or a collection of electronic devices such as power supplies.) The ship systems added by the IDA study group are RF devices that are listed as potential attractive applications for CASS by the NAVSEA-04D CASS Business Plan. We obtained the test requirements for the Marine Corps aircraft systems from an NAWC Tiger Team. The Marine Corps ground systems were selected from among those analyzed in the Marine Corps Cost and Operational Effectiveness Analysis for the proposed Third Echelon Test Set (the TETS COEA). The test requirements for these systems were compiled by the Marine Corps Logistics Base at Albany, GA.

The Air Force maintains the ECAC database for the purpose of planning joint military operations free of interference and other electronic compatibility problems. We obtained ECAC data for a sample of 144 Navy, Marine, and Air Force avionics systems. With the data from the SSM and ECAC databases, we were able to analyze test requirements for all Services except the Army. (Some of the Marine Corps ground systems, however, are similar to Army ground systems.)

The results of the hardware analysis indicate that CASS is a highly capable tester: it can meet the test requirements of most of the Navy and Marine systems represented in the SSM database, as well as most of the Air Force requirements obtained from the ECAC

database. The analysis shows, however, that there are some near-term improvements worth considering. Table S-1 lists these improvements, for a nominal buy of 100 units. The development costs are less than $1 million and the 10-year costs are less than $7 million.

The improvements are motivated by several considerations: some are designed to remove current testing shortfalls, others would bring generally useful increases in CASS functionality and operability, and still others would take advantage of new electronics technology. The testing shortfalls are defined as those test characteristics for which CASS fails to meet the requirements of 85 percent of the systems.

We chose an envelope approach to identify shortfalls because of the massive amounts of requirements data. *Although this approach reduced the scope of the analysis to manageable proportions, it also led to a downward bias in estimating CASS capability.* For example, the "maximum RF stimulus power" test requirement for the Marine Corps AN/MRC-142 digital communications package was set as 33 dBm, which is the highest test requirement (the envelope) of all of the WRAs (weapon replaceable assemblies black box sub-systems) that comprise the system. Because CASS has a capability of only 16.5 dBm for this test, it was judged unable to meet the RF stimulus power requirement for the AN/MRC-142, despite the possibility that only a few of the WRAs required 33 dBm. In fact, CASS could actually meet the requirements for most of the WRAs.

Because of this bias against CASS, the costs shown in Table S-1 are over-estimates.

An additional set of improvements was constructed to meet shortfalls that do not exist at present, but which might arise in the future:

- RF Stimuli (Frequency Extension and Maximum Output)
- RF Power Measurement (Frequency Extension)
- DC Resistive Load
- Phase Noise Measurement
- Noise Figure Measurement
- RF Interface Switching
- Pulse and Waveform Generator Voltage Output
- Digital (Stimuli and Measurement)

Upgrades to meet these shortfalls would cost $21.88 million (FY 1995 dollars) over 10 years for installation and support in 100 CASS stations. Although implementation of these features is not recommended for the present, we suggest that the Program Office ensure that the technology for meeting these needs is under development.

Table S-1. Near-Term Recommendations of Part 1 Analysis

		Costs (FY 1995 Dollars)		
Test Area	Recommendation	Development Dollars	Unit Procurement Dollars	10-Year Dollars (Millions)[a]
RF Stimulus, Minimum Output	Add a programmable attenuator		$2,500	$0.57
RF Synthesizer Replacement	Replace the 20 and 40 GHz synthesizers with MMS architecture units		$3,500	$0.97
Power Measurement, Maximum Power	1. Add a sensor to increase power to +44 dBm		$1,820	$0.31
	2. Add an attenuator		$480	$0.11
Resistive Load RF	1. Add a 1,000-watt load that can operate from DC to 2.5 GHz		$895	$0.20
	2. Develop a RF load accessory	$760,000	$15,200	$3.40
RF Noise	Activate RF noise measurement		$5,000	$1.13
Total				$6.69

[a] For a nominal buy of 100 units.

There are important caveats to this analysis. First, some of the improvements in capability that we have recommended might be included in the design competition that the Navy is now conducting (summer 1995) for the High Power Device Tester. The results of this competition could obviate the need for some of these improvements, thus lowering the cost of the short- and long-term packages listed above. The second caveat is that our analysis takes no account of the many old single-purpose testers that are still around. Our objective has been to identify upgrades that would enable CASS to meet *all* test requirements. These upgrades will help the Navy reach its long-term goal of replacing all the single-purpose testers with CASS, and thereby obtain the benefits of lower logistic support for testers, standardized training of maintenance personnel, and lower stockage requirements for electronic systems. During the transition, however, it could be economical to rely on some of the existing, single-purpose testers, rather than adopting some of the short-term options we have considered, such as putting active elements in the Interface Devices. We have not undertaken the substantial analysis to study the most

efficient strategy for (a) producing new CASS stations, (b) making improvements to the existing stations, (c) developing new TPSs, and (d) retiring the older testers.

Appendix C is a brief analysis of possible new, downsize CASS configurations. The current CASS configurations—Hybrid, RF (radio frequency), CNI (communications, navigation, identification), and EO (electro-optical)—are 5- and 6-bay systems that can only be installed where space is available, such as on aircraft carriers and amphibious ships, and at shore-based maintenance facilities and factories. Smaller, or downsize, CASS configurations could be developed for use on smaller Navy combatants and with Marine Corps 2nd and 3rd echelon mobile field units, as well as at shore locations that do not need a full-size CASS system.

Our analysis indicates that the current CASS architecture could be downsized to a 1-1/2 bay configuration that would retain a significant degree of functional capability. Software modifications to ensure that the TPSs would be interchangeable between full and downsize CASS configurations are analyzed in Part 2 of this study. Because of the potential reductions in cost and increases in the applicability of the CASS system, we recommend that the CASS (Aviation Support Equipment) Program Office sponsor detailed study of CASS downsize configurations.

Part 2. Software Analysis

The software analysis addresses four Tasks. Tasks 1 and 2 deal with compatibility between alternative CASS configurations. The analysis in Task 1 indicates that current CASS software will allow for TPS compatibility across different full CASS configurations, and upward compatibility from downsize to full CASS stations. Upward compatibility would be needed, for example, if an electronics item that failed a go/no-go test on a carrier escort were transferred to the aircraft carrier for diagnosis and repair.

The analysis in Task 2 shows that downward compatibility is a problem, but it could be eliminated by a relatively small non-recurring cost of $125,000 to upgrade the station software. This change would permit TPS developers to construct multiple-configuration TPSs that would run on all platforms, thus avoiding the costs of developing single-configuration TPSs for each platform.

Tasks 3 and 4 deal with the more general topic of improving the overall operability of CASS software. Task 3 recommends the following actions for short-term consideration:

- Restrict the use of hardware-dependent programming, which reflects the particular idiosyncrasies of the station computer, and FEPs (Functional Extension Programs) involving subroutines not written in ATLAS, the standard language used for test software.
- Add digital capability to the ATLAS station through the existing DO DIGITAL constructs.
- Encourage the use of existing software tools and sponsor the development of new tools for constructing TPSs.
- Add sections regarding the above topics to the Style Guide and Red Team Package that provide guidelines for TPS developers.
- Strengthen the role of the Designated Government Acceptance Representatives (DGARs) who supervise the construction of TPSs so that they can help enforce the restrictions listed under the first and third items above.

Task 4 lays out a detailed long-term roadmap of steps that will bring CASS into conformity with recent OSD policy requiring increased use of commercial standards in designing testers, and that will allow CASS to take advantage of new software standards and languages being studied and developed for the Institute of Electrical and Electronic Engineers (IEEE).

INTRODUCTION

BACKGROUND

The Office of Secretary of Defense (OSD) has embarked on a long-term program to reduce the costs of testing electronic equipment. The ultimate goal is to replace the multitude of single-purpose testers that are tailored for individual weapon systems with few highly-capable testers that can each test a wide range of electronic systems. OSD's strategy for reaching this goal is to eliminate investments in automatic test systems that are unique to particular weapon systems and which duplicate capabilities already in DoD.[1] New capability required by new weapons would be obtained, to the extent possible, by expanding the performance of existing multi-purpose test systems. By cutting down on the number of new systems, we should be able to save on the costs of development, procurement, and logistics support (through reduced range of spares and fewer training syllabi).

Another facet of OSD's strategy is to develop a DoD-standard test environment that will reduce the time and cost of developing test programs and lead to further savings by permitting greater use of commercial components and software.

As a contribution to this initiative, the Navy developed the Consolidated Automated Support System (CASS) to test virtually all Naval electronics systems. CASS is a multi-bay system that was originally developed to replace the multitude of smaller and unique avionics testers, as well as the larger VAST tester, at the Navy intermediate maintenance departments located aboard aircraft carriers and at intermediate and depot-level facilities ashore. Several CASS configurations are being developed, procured and

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1 CASS is referred to as an Automatic Test System (ATS). An ATS consists of (a) Automatic Test Equipment (ATE) hardware and operating system software, (b) Test Program Sets (TPSs) that include the hadware connectors and software programs to test individual electronic systems (Units Under Test, or UUTs), and (c) associated software environments used in the development of ATE and TPS software. ATSs are used in DoD intermediate-level and depot-level maintenance facilities to test electronics systems that are difficult or impossible to test manually, to reduce troubleshooting times, and to augment the skills of field technicians. ATSs are also used in manufacturing in-process testing and acceptance testing.

fielded: Hybrid (the basic configuration for analog and digital functions), RF (Radio Frequency), CNI (Communication, Navigation, and Identification), and EO (Electro-Optical). The Office of Secretary of Defense (OSD) and the Navy are now considering expanding the mission of CASS in several dimensions: testing all electronics, not just avionics; developing stations for use on smaller Navy ships such as carrier escorts and amphibious ships; and testing electronics for Services other than the Navy. Some EO (Electro-Optical) stations will be created by combining some of the Hybrids with a separate Electro-Optics SubSystem (EOSS), but this system has not yet been completely defined.

In early 1995, the Navy signed a contract with Lockheed Martin to produce the final 400 units of a total buy of 700 stations (maximum values). The total cost of these last 400 units is approximately $530 million, an average cost of approximately $1.3 million each.

OSD has since designated CASS as one of two initial DoD families of automatic test systems to be considered for application to Navy shipboard electronics, as well as to the electronics of the other Services. To help meet this expanded role, PMA-260 asked IDA to study two test areas: (1) the ability of CASS instruments to meet the hardware requirements of the electronics of the Navy, Marine Corps, and Air Force and (2) the software issues involved in extending the role of CASS. The study was sponsored by the Director, Industrial Capabilities and Assessments (formerly Weapon Support Improvement Group), Office of the Assistant Secretary of Defense (Economic Security). The study was directed to support the Aviation Support Program Office (PMA-260) in the Naval Air Systems Command (NAVAIR), the office that manages the CASS program.

The focus of the present study is on using CASS for testing the following: avionics on Navy aircraft, electronics on Navy carriers and smaller ships, avionics on Marine Corps aircraft, and electronics in Marine Corps ground systems.

Because of space constraints, using CASS at sites other than large ships (e.g., aircraft carriers) and shore intermediate maintenance sites and depots will require the development of new, downsize configurations that contain subsets of the components (stimulus and measurement instruments, power supplies, etc.) that are found on the full CASS configurations. Such stations will therefore be able to perform only a subset of the tests that can be accomplished using the full-size configurations.

Expanding the mission of CASS not only requires new hardware, but also raises some questions regarding software. There are issues of capability and compatibility

regarding the software in the CASS stations and in the various Test Program Sets (TPSs)[2] that enable the stations to test the thousands of electronics systems. We analyze the question of software compatibility in the second part of this study. In addition, we will analyze other issues concerning general improvements to reduce the cost and improve the software capability of CASS station and TPS software. Finally, we will consider some changes to CASS software that will be needed in response to recent OSD directives that require greater use of commercial design standards to benefit from evolving software standards being developed by the Institute of Electrical and Electronic Engineers (IEEE).

STUDY TASKS

The analysis is presented in two parts. Part 1 and its appendices focus primarily on hardware improvements to meet RF requirements (plus some related analog and digital needs). This analysis is carried out by identifying the hardware requirements of Navy aircraft and ships and Marine aircraft and ground systems. To identify shortfalls, we compared these requirements to the current test capability of CASS. Then we developed improvements to remove these shortfalls as well as to achieve other gains in capability. We estimated the 10-year costs of the improvements.

The appendices list the data used in the analysis (Appendix A), describe the cost model used to generate the estimates of 10-year cost (Appendix B), and present a brief analysis of the possibilities for developing downsize CASS configurations for use in smaller Navy ships and with deployed Marine forces (Appendix C). The cost model was developed in an earlier IDA study of CASS (Reference 1); Appendix B describes its main features.

Part 2 of the study deals with CASS software, including that in the station itself and in the TPSs that direct the tests of individual systems. The software analysis is divided into four tasks. Tasks 1 and 2 identify improvements to ensure the compatibility between current and new CASS configurations. Task 3 analyzes modifications to improve the operation of CASS software in general, and Task 4 provides a long-term roadmap to move CASS toward a more open architecture.

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2 TPSs are the collections of hardware and software that are used to test a given UUT at a given CASS station. A TPS consists of software (on an optical disk), the interface device (ID) that attaches to the CASS panel, the cables that attach the interface device to the UUT, and the required documentation to run the TPS and maintain the ID.

PART 1
HARDWARE ANALYSIS

I. METHODOLOGY

A. OVERVIEW

The objective of the hardware analysis is to compare test requirements with CASS capability in order to identify shortfalls, identify options for alleviating these shortfalls, and make other improvements as well. Individual sections of this chapter describe how the systems were selected for analysis (Section B), the sources of requirements data (Section C), the forming of detailed requirements into more aggregate test envelopes for purposes of convenience (Section D), and the capability of CASS (Section E).

Chapter II analyzes a database of Navy and Marine Corps systems in order to test characteristics for which CASS has a shortfall. The study arbitrarily defines a shortfall as a test characteristic for which CASS meets the requirements in fewer than 85 percent of the systems. The shortfalls were all determined using the Synthesis System Model (SSM) database (described later), which contains data for Navy and Marine Corps systems. As an example, we have identified "RF stimulus maximum output" as a shortfall because CASS fails to meet the requirements of 21 of the 35 Navy and Marine systems in our database that require RF stimulus (see Table 1-3 in Chapter II). The success rate of 40 percent is far short of our 85 percent criterion. Chapter III analyzes each shortfall to identify remedies. Chapter III also analyzes data from the Electromagnetic Compatability Analysis Center (ECAC) database (which contains information for Air Force as well as Navy and Marine systems) in order to identify an additional set of improvements that are not designed to remedy shortfalls, but rather to add new test functionality, to improve CASS operability, and to take advantage of new technology.

Chapter IV summarizes the improvements and gives the 10-year costs of each. The model for estimating these costs was developed in an earlier IDA study of CASS (Reference 1). The costs are estimated by summing the nonrecurring costs of development, integration, and procurement of an illustrative 100 units and adding to that the recurring costs of operating and maintaining the upgrade for 10 years. (We lacked the resources to estimate the procurement costs based on the actual number of CASS units to be improved.) Development costs are not incurred in cases involving COTS (Commercial Off-The-Shelf) devices; integration costs are paid only for those upgrades that involve

modification of the CASS station itself, rather than addition of external accessories or changes to the Test Program Sets (TPSs) that apply the CASS station to the particular test at hand.

Whereas the analysis of improvements to reduce the shortfalls used data from the Navy's SSM database, the improvements that are directed at CASS functionality, operability, and technology draw on the ECAC database as well.

There is a general point that must be kept in mind in reading the analysis in Part 1. The Navy is now (summer 1995) in the process of reviewing proposals for a High Power Device Tester. The HPDT will be a major add-on to CASS, and might include instruments for relieving some of the shortfalls in CASS capability that are analyzed in this study. The design of the HPDT will not be known, however, until the review process is completed. For this reason, the discussions of possible improvements to CASS in Part 1 include the implicit option of deferring remedial action until the HPDT design becomes known.

B. SELECTION OF SYSTEMS FOR ANALYSIS

We chose the systems whose test requirements are analyzed by applying the criteria shown below to data in the SSM database. We excluded systems with a small number of items and a short remaining service because they were not likely candidates for development of costly upgrades.

- There are more than 75 systems in existence.
- The systems have a remaining service life greater than 5 years.
- Substantial data on test requirements are available.

Table 1-1 lists the systems that meet these criteria.

C. SOURCES OF DATA FOR TEST REQUIREMENTS

We obtained test requirements (both stimulus and measurement) for the above systems from two sources: the System Synthesis Model (SSM) maintained by the Naval Air Warfare Center (NAWC), Aircraft Division at Lakehurst, NJ, and the ECAC maintained by the Air Force at Annapolis, MD.

1. SSM Database

The System Synthesis Model (SSM) contains the characteristics of electronics systems for Navy aircraft, Navy ships, and Marine Corps aircraft. At the start of the study,

the SSM contained characteristics for approximately 1,900 WRAs (Weapons Replaceable Assemblies) and SRAs (Systems Replaceable Assemblies). WRAs are electronic modules, and SRAs are the circuit cards contained in the WRAs. Both are referred to as Units Under Test, or UUTs.

To increase the coverage of the SSM data for the present analysis, the IDA study group inserted data for an additional 20 systems: 6 Navy ship systems including the NAVSEA (Naval Sea Systems Command) CEC (Cooperative Engagement Capability), 8 Marine Corps aircraft systems, and 6 Marine Corps ground systems. The final SSM database consists of 99 electronics programs representing 1,232 UUTs: 746 UUTs for Navy aircraft, 130 for Navy ships, 282 for Marine aircraft, and 74 for Marine ground systems. (The SSM lists data for electronics "programs." A program can be a complete system such as an F/A-18 C/D radar or a collection of electronic devices such as power supplies.)

The ship systems added by the IDA study group are RF devices listed as potential applications for CASS by the NAVSEA-04D CASS Business Plan. The data for these systems were obtained from technical manuals and from the Naval Surface Warfare Center at Dahlgren, VA. An NAWC Tiger Team compiled the test requirements for the Marine Corps aircraft systems. The Marine Corps ground systems we selected for analysis were from among those analyzed in the 1993 Marine Corps Cost and Operational Effectiveness Analysis for the proposed Third Echelon Test Set (the TETS COEA). TETS is planned to be a mobile automated tester that could be used by deployed Marine Corps ground forces. The test requirements for these systems were compiled by the Marine Corps Logistics Base at Albany, GA.

Tables A-1a through A-1g in Appendix A list the requirements obtained from the SSM database.

Table 1-1. Systems Selected for Analysis

Platform	Nomenclature	Description of System	Data Source
Navy Aircraft	A-6	Avionics	SSM
	AV-8B	Avionics	SSM
	EA-6B	Avionics	SSM
	F-14D	Avionics	SSM
	F/A-18 E/F	Avionics	SSM
	S-3	Avionics	SSM
	SH-60	Avionics	SSM
	Avionics packages	Avionics	SSM
Navy Ships	ACSSIS	Electronics system	SSM
	AN/BQQ-5	Sonar	SSM
	AN/BQQ-9	Sonar	SSM
	AN/SLQ-32	Electronic warfare	Technical data
	AN/SQQ-89	Sonar	Tiger Team
	AN/USC-38	Satellite communications	Technical data
	AN/UYQ-21	Navy Tactical Data System	SSM
	AN/UYS-2	Signal processor	SSM
	CEC	Cooperative Engagement Capability	Tiger Team
	AN/URC-131	HF radio group	Technical data
	AN/USQ-122	High Speed Fleet Broadcast	Technical data
	MK-78	Fire control	SSM
	MK-116	Underwater fire control	SSM
	MK-117	Fire control	SSM
	MK-118	Fire control	SSM
	MK-122	Electronics system	SSM
	MK-408	Electronics system	SSM
Marine Corps Aircraft	AH-1W	Helicopter avionics	Tiger Team
	AV-8B	Avionics	Tiger Team
	CH-53	Avionics	Tiger Team
	EA-6B	Avionics	Tiger Team
	F/A-18 C/D	Avionics	Tiger Team
	F/A-18 E/F	Avionics	Tiger Team
	KC-130T	Avionics	Tiger Team
	MV-22	Avionics	Tiger Team
	UH-1N	Helicopter avionics	Tiger Team
Marine Corps Ground Systems	AN/MRC-142	Digital communications	Albany, GA
	AN/PPS-15A	Personal radar	Albany, GA
	AN/TRC-170	Troop scatter	Albany, GA
	AN/TSQ-129	Position location reporting	Albany, GA
	SCAMP	Satellite communication terminal	Albany, GA
	SINCGARS	Secure communications	Albany, GA

2. ECAC Database

The test requirements for 144 Navy, Marine, and Air Force avionics systems, and other electronic systems were obtained from the Air Force's ECAC database. This database lists operating frequency and other electronic system characteristics used to plan joint operations free of interference and other electronic compatibility problems. Although these characteristics are not test requirements per se, we took them as reasonable proxies for test requirements. Table A-2 in Appendix A lists the requirements obtained from the ECAC database.

D. TEST REQUIREMENTS ENVELOPES

The full set of SSM test requirements constitutes a massive database involving almost 60,000 data points (1,232 UUTs x 48 characteristics). To reduce the scope of the analysis, we aggregated the SSM data using the envelope reports generated by the SSM model. For each system and test characteristic, an envelope report lists the maximum or minimum value over all the WRAs and SRAs that are contained in the system (and for which data are listed in the SSM database).

To illustrate, the envelope for the AN/MRS-142 system used by Marine ground forces includes a single number for maximum RF stimulus frequency, rather than one such frequency for each of the 30 WRAs and SRAs that comprise the system. This approach reduces the number of data points by a factor of 12, from 60,000 to approximately 5,000 (99x48).

Although the use of envelopes reduces the scope of the analysis to manageable proportions, it biases the results against CASS. CASS meets an envelope requirement only if it meets the requirements for all UUTs that comprise the system. The proportion of envelope requirements that are met is thus an underestimate of CASS capability. For example, CASS might fail to meet the envelope requirements for a system even though it meets the requirements for 99 percent of the WRAs and SRAs that comprise the system. Our calculations thus understate CASS capability to meet test requirements.

E. CASS CAPABILITY

Table 1-2 describes CASS capability using data obtained from the CASS Prime Item Development Specification and from the Configuration Item file contained in the SSM reference documentation. For example, the first entry in the table shows that DC Power can be provided by any of three CASS power supplies or the Low Frequency Calibrator, each with its own range of characteristics. As another example, the function of waveform generation is provided by the Arbitrary Waveform Generator, which provides a frequency range of .01Hz–250 MHz.

Table 1-2. CASS Test Capability

Test Category	Instrument	Characteristics
DC Power	100 VDC Power Supply	100 VDC, 8 amps
[450V]	32 VDC Power Supply	32 VDC, 25 amps (May be operated in parallel to provide 115 amps)
	450 VDC Power Supply	450 VDC, 3.8 amps
	Low Frequency Calibrator	200 VDC, 0.05 amps
AC Power	115 VAC Monitor	200 VRMS, 420 Hz, 30 amps, 3 phase
[30 amps @ 200VRMS, 420 Hz]	135 VAC Power Supply	135 VAC, 400 Hz, 7.6 amps, 3 phase
[2.2 amps @ 200VRMS, 1e+05 Hz]	Low Frequency Calibrator	200 VRMS, 100 KHz, 2.2 amps, single phase
DC volts Measurement	Digital Multimeter	1,000 VDC
[1,000 VDC]	Programmable Power Load	500 VDC
DC Current Measurement	Digital Multimeter	2 amps
[20 amps]	Programmable Power Load	20 amps
AC Current Measurement [2 amps]	Digital Multimeter	2 amps
Resistance Measurement [3 e+07 ohms]	Digital Multimeter	30 Mohms
Pulse Generation [+/- 10V; 250 MHz]	Arbitrary Waveform Generator	Pulse Repetition: 100 sec. max; 40 nano sec. min Pulse Width: 100 sec max.; 40 nano sec min. Voltage: +10 volts max; -10 volts min
	Pulse Generator	Pulse Repetition: 0.099 sec max; 4 nano sec min Pulse Width: 0.089 sec max; 2 nano sec min
Waveform Generation [10 v P-P; 25 MHz]	Aribratary Waveform Generator	Frequency: 25 MHz max; 0.01 Hz min, 10 volts P-P
AC Voltage Measurement [700 VRMS]	Digital Multimeter	700 VRMS
Frequency Measurement	Frequency Time Interval Counter	Frequency 200 MHz max; 200 KHz min, 0.035 volts min
[26.5 GHz]	Microwave Transition Analyzer	Frequency 2.65 Hz e+10 max
	Waveform Digitizer	Frequency: 500 MHz max
Time Interval Measurement	Frequency Time Interval Counter	Time Int: 1,500 sec max; 4 nano sec min, 0.035
[4 nsec]		min volts
Complex Waveform Measurement	Microwave Transition Analyzer	Frequency: 26.5 GHz max; 0.1 Hz min
[0.1 Hz to 26.5 GHz]	Waveform Digitizer	Frequency: 500 MHz max; 0.03 Hz min
Pulse Measurement [26.5 GHz; 3.8e-11 sec]	Microwave Transition Analyzer	Repetition Rate: 20 sec max; 38 pico sec min Pulse Width: 20 sec max; 38 pico sec min
	Waveform Digitizer	Repetition Rate: 50 sec max; 2 nano sec min Pulse Width: 50 sec max; 200 pico sec min, 0.1 mvolt min
Digital Stimulus [336 pins; 4e+07 B/S; +15 v to -5 v]	Digital Test Unit	336[a] pins max; Data Rate: 40 Mbs max; .05 amps; High volts 15 max, Low Volts -5 min
Digital Measurement [336 pins; 4e+07 B/S; +13.5 v to -5 v]	Digital Test Unit	336[a] pins max; Data Rate: 40 Mbs max; High volts 13.5 volts max, Low Volts -5 min

Table 1-2. CASS Test Capability (Continued)

Test Category	Instrument	Characteristics
Resistive Load [500 W @ 9.99e+04 ohms] [0.01 W @ 1.9e+07 ohms]	Low Frequency Calibrator Programmable Power Loads	Ohms 19 million; Power 0.01 watts max Ohms 99.9 thousand max; Power 500 watts max
RF Stimuli [8.3 dBm @ 40 GHz] [16.5 dBm @ 20 GHz]	Comstron Signal Generator Frequency Synthesizer High Pwr Synthesizer Generator	Frequency: 6.6 GHz max; Power Out: 10 to -100 dBm Frequency: 40 GHz max; Power Out: 8.3 to -100 dBm Frequency: 20 GHz max; Power Out: 16.5 to -100 dBm
RF Measurement [44 dBm to -140 dBm]	Power Meter Spectrum Analyzer Microwave Transition Analyzer	Frequency: 50 GHz max; Power In: 44 to -70 dBm Frequency: 2.2 GHz max[b]; Power In: 20 to -140 dBm Frequency: 265 GHz max; Power In: 0.01 to -60 dBm

[a] 168 pins are available for data rates above 20 MHz.
[b] Extendible to 220 GHz with external mixers.

F. CAVEATS

In Part 1 of this study, we have occasionally used specific instruments and catalog prices to describe some of the improvements to CASS. This was done solely for illustration, to show that such instruments exist. There was no attempt to find the best versions and prices; instruments with similar characteristics produced by other manufacturers would work just as well.

The second caveat is that our analysis takes no account of the many old single-purpose testers that are still around. Our objective has been to identify upgrades that would enable CASS to meet *all* test requirements. These upgrades will help the Navy reach its long-term goal of replacing all the single-purpose testers with CASS, and thereby obtain the benefits of lower logistic support for testers, standardized training of maintenance personnel, and lower stockage requirements for electronic systems. During the transition, however, it could be economical to rely on some of the existing, single-purpose testers, rather than adopting some of the short-term options we have considered, such as putting active elements in the Interface Devices. We have not undertaken the substantial analysis required to find the most efficient strategy for (a) producing new CASS stations, (b) making improvements to the station, (c) developing new TPSs, and (d) retiring the older testers.

Three additional considerations in our analysis apply. First, CASS improvements that bring large increases of coverage do the most toward furthering the Navy's objective of replacing virtually all the existing single-purpose testers with CASS in order to increase on capability and save on operating and support costs. Second, it is inefficient to improve CASS's ability to test unique characteristics of systems that are soon to retire. Third,

assuming that CASS is generally a better tester than the older, single-purpose testers, we obtain the highest gains in readiness by increasing CASS's ability to test the more critical systems. Although we have included data on the populations and lifetimes of the systems in our analysis, assessing the relative criticality of various systems is far beyond the scope of the present study. Some of the programs we have analyzed from the SSM database involve pilot safety, some involve ship navigation, and so on. In addition, the programs listed in the SSM database differ widely in complexity and scope, from manpack radios to complete avionics suites on fighter aircraft. We would have liked to include these issues of criticality and complexity in our analysis, but the SSM database does not present the relevant information.

The 10-year costs of the hardware improvements considered in Part 1 are limited to the costs of the CASS stations. The effects of changes on the costs of the TPSs are not considered. Finally, as mentioned earlier, the use of an envelope approach in the analysis results in a bias against CASS. The costs of the improvements are thus overestimates.

II. IDENTIFICATION OF TESTING SHORTFALLS

Table 1-3 contains the results of the shortfall analysis, on which we based many of the recommendations for CASS improvements. The requirements in this table are taken from the SSM database. The identification of the improvements in Chapter III draws on the ECAC data as well. Table 1-3 lists for each test characteristic and each type of platform (e.g., Navy aircraft) the total number of "Applications" (programs for which there are requirements data) and the number of "Exceptions" (programs for which CASS failed to meet the requirements). We listed the failures rather than the successes to keep the numbers small.

To illustrate, the figures in the upper left-hand corner of the table show that the database contains information on RF stimulus frequency for 23 of the Navy aircraft programs, and that CASS meets all 23 requirements (0 exceptions).

The bottom three rows of Table 1-3 present summary data over all 48 test characteristics. The left-most figures show, for example, that CASS has a fairly high coverage of 90.1 percent for Navy aircraft systems (177 exceptions out of a total of 1,796 programs for which the SSM has data). The averages for Navy ships and Marine ground systems are also around 90 percent, but the coverage for Marine aircraft is somewhat lower, at 85.9 percent. Overall, the coverage is 89.5 percent.

For purposes of the analysis, we will focus on the three right-hand columns of the table, which present summary information for each test characteristic over all types of platforms. The top figures, for example, show that for the first characteristic of RF stimulus frequency, the database contains information on 43 applications, and that CASS was able to meet the requirements for all but one of these programs, yielding a coverage of 97.7 percent.

CASS meets a similarly high percentage of requirements for almost all of the test category requirements shown in the table, even though the requirements are drawn from more types of platforms than CASS was originally designed to satisfy. However, using a coverage of 85 percent as our criterion of "acceptable" in this study, CASS fails to meet acceptable levels for 10 of the test characteristics, for which we will seek improvements in Chapter III. In addition, we will consider a shortfall in RF stimulus minimum power that

came to light using the ECAC data. Table 1-4 shows the shortfalls obtained using SSM data. Note that they are not due solely to the "extended" requirements for CASS—for Navy ships and Marine Corps aircraft and ground systems. Although shortfalls exist for these platforms, the figures in Table 1-3 indicate that CASS fails to meet 85 percent coverage for Navy aircraft as well.

Before proceeding further, however, we determined which of these 10 characteristics were needed by many systems. We gathered the percentage of use figures in Table 1-4 to guard against recommending costly improvements to hundreds of CASS stations to cover test characteristics that are required by only a few systems. The percentages were calculated by dividing the number of programs for which the characteristic is listed as a test feature, by 99, the total number of programs. With one exception, all of the test characteristics listed in Table 1-4 have relatively high Percentage of Use. For this reason, none of them were eliminated from "needing improvement." Note that the "Percentage of Use" understates usage because some of the programs for which a given test characteristic is not listed in the SSM database are cases of missing data, rather than cases in which the characteristic was actually not needed.[1]

Since some of the missing entries in the SSM database probably *are* cases of missing data, rather than cases for which the test characteristic is not needed, the coverage figures in Table 1-4 are underestimates. The fact that almost all of these figures are, nevertheless, relatively high indicates that the test characteristics listed in Table 1-4 are indeed cases of substantial importance for coverage by CASS.

[1] For example, a characteristic that has data entries for 50 of a total number of 100 programs would yield a percentage of use of 50 percent, using our procedure. This would be the true coverage if all the empty cells were cases in which the test characteristic were really not needed. On the other hand, if the 50 empty cells were cases of missing data, that would mean that CASS met the requirements for *all* the programs for which data existed. The best estimate for the coverage of CASS would then be 100 percent.

Table 1-3. CASS Capability To Meet Test Requirements Listed in the SSM Database

	Navy Aircraft		Navy Ships		Marine Aircraft		Marine Ground		Totals		
Test Category	Appli-cations	Excep-tions	Appli-cations	Excep-tions	Appli-cations	Excep-tions	Appli-cations	Excep-tions	Appli-cations	Excep-tions	Coverage
RF Stimulus											
Frequency	23	0	5	1	6	0	9	0	43	1	97.7
Max Output (16.5 dBm)	19	13	5	4	4	2	7	2	35	21	40.0
Min Output	20	1	5	2	4	0	7	1	36	4	88.9
RF Power Measurement											
Frequency	25	0	6	0	6	0	9	0	46	0	100.0
Max Power	22	5	6	3	6	5	9	5	43	18	58.1
Min Power	21	0	6	0	6	0	9	0	42	0	100.0
Resistive Load											
Max Resistance	38	2	7	0	4	0	9	0	58	2	96.6
Max Power	35	9	6	1	4	0	9	1	54	11	79.6
Frequency Measurement										0	
Max Hz	33	0	5	2	6	1	6	0	50	3	94.0
Min Voltage	22	1	1	1	2	0	4	0	29	2	93.1
Time Interval											
Max Sec	29	0	4	0	1	0	7	0	41	0	100.0
Min Sec.	30	1	4	0	1	0	7	0	42	1	97.6
Min Volts	24	3	2	0	0	0	5	1	31	4	87.1
Pulse Generation											
Max Repetition Period	39	0	6	0	4	0	7	0	56	0	100.0
Min Repetition Period	39	1	6	0	4	0	7	0	56	1	98.2
Max Pulse Width	40	0	6	0	2	0	8	0	56	0	100.0
Min Pulse Width	40	1	6	1	2	0	8	1	56	3	94.6
Max Output Voltage	35	18	5	1	1	0	6	5	47	24	48.9
Waveform Generation											
Max Frequency	43	5	9	1	4	0	9	1	65	7	89.2
Min Frequency	38	0	9	0	4	0	9	0	60	0	100.0
Max Volts	42	21	7	1	3	0	9	6	61	28	54.1
Pulse Measurement											
Max Repetition Period	35	0	2	0	2	0	8	1	47	1	97.9
Min Repetition Period	35	1	2	0	2	0	8	0	47	1	97.9
Max Pulse Width	35	0	1	0	2	0	8	0	46	0	100.0
Min Pulse Width	34	0	1	0	2	0	8	0	45	0	100.0
Min Voltage	12	0	2	0	1	0	5	0	20	0	100.0
Waveform Measurement											
Max Frequency	35	0	8	0	3	0	9	0	55	0	100.0
Min Frequency	34	0	8	0	3	0	9	0	54	0	100.0
Min Voltage	34	0	3	0	2	1	9	0	48	1	97.9
Digital Stimulus											
Pin Quantity	54	1	12	1	4	0	9	0	79	2	97.5
Max Data Rate	44	3	9	0	4	0	9	0	66	3	95.5
Max Voltage	52	18	15	0	5	1	9	5	81	24	70.4
Max Drive	29	12	11	3	0	0	8	4	48	19	60.4
Digital Measurement											
Pin Quantity	55	2	7	2	4	0	9	0	75	4	94.7
Max Data Rate	48	1	6	0	4	0	9	0	67	1	98.5
Max Voltage	50	16	9	1	4	0	9	9	72	26	63.9
Min Voltage	50	2	9	2	4	2	9	3	72	9	87.5
Min Drive	26	4	7	0	0	0	8	2	41	6	85.4
DC Power Supplies											
Max Volts	65	7	16	0	6	0	9	1	96	8	91.7
Max Current	59	0	16	1	4	0	9	0	88	1	98.9
AC Power Supplies											
Max Volts (RMS)	57	3	9	2	3	2	9	1	78	8	89.7
Max Current	51	5	4	2	1	0	7	1	63	8	87.3
Max Phases	44	0	9	1	2	0	8	0	63	1	98.4
Digital Multimeter											
Max DC Volts	65	8	16	0	6	0	9	0	96	8	91.7
Max DC Current	41	10	13	0	4	0	9	1	67	11	83.6
Max AC Current	3	2	0	0	1	1	2	2	6	5	16.7
Max AC Volts	43	1	11	0	4	0	9	0	67	1	98.5
Max Resistance	49	0	3	1	3	0	9	1	64	2	96.9
Total Applications	1,796		325		154		383		2,658		
Total Exemptions		177		34		15		54		280	
Percentage Covered	90.1%		89.5%		90.3%		85.9%		89.5%		

Table 1-4. Test Categories for Which CASS Meets Less Than 85 Percent of System Requirements

Test Category	CASS Coverage (%)	Percentage of Use (%)
RF		
Power Stimulus, Maximum Power	40.0	35.3
Power Measurement, Maximum Power	58.1	43.4
Resistive Loads, Maximum Power	79.6	54.5
Analog		
Pulse Generation, Maximum Output Voltage	48.9	47.5
Waveform Generation, Maximum Volts	54.1	61.6
Digital Multimeter, Maximum AC Current	16.7	6.1
Digital Multimeter, Maximum DC Current	83.6	67.7
Digital		
Digital Stimulus, Maximum Voltage	70.4	81.8
Digital Stimulus, Maximum Drive (Current)	60.4	48.5
Digital Measurement, Maximum Voltage	63.9	72.7

III. OPTIONS TO IMPROVE CASS PERFORMANCE

A. INTRODUCTION

This chapter identifies options and estimates their 10-year costs for improving CASS. As described earlier, the improvements have several objectives. Some are designed to relieve the shortfalls (coverage under 85 percent) that were indicated by the analysis of SSM data in Table 1-4. Other improvements, which are first considered in this section, or designed to achieve one of the following benefits: (1) adding new test functionality (i.e., wholly new tests), (2) improving the general operability of the CASS station, or (3) taking advantage of new technology. These latter improvements are derived by considering both sources of data, ECAC as well as SSM.

The improvements in the areas of RF, analog, and digital are discussed in sections B, C, and D, respectively. Each section includes a discussion of the issue, a description of the alternatives, and an estimate of the development and procurement costs that are used to generate the 10-year costs shown in Chapter IV. The model for generating these 10-year costs was developed for the earlier IDA study (Reference 1), and is summarized in Appendix B of the present study. Chapter IV shows the recommended alternatives and their 10-year costs.

Table 1-5 lists the section in which each improvement is analyzed, along with a notation to show the principal objectives of the improvements.

The alternatives to be analyzed can be implemented using one or more of the following mechanisms:

- *Engineering Change Proposals (ECPs)* to the station are recommended in those cases for which the required technology is currently available at a relatively small cost, and for which the proposed change would affect a significant population of UUTs.
- *External accessories* such as a mobile cabinet of power loads are considered for cases in which an ECP appears to be an unattractive solution because the system has a short remaining life or a low population of items.
- *Active components incorporated in the ID (Interface Device) of the TPS* are considered, along with external accessories, in meeting test requirements that

involve a small population of systems, and where the improvement would not significantly increase the complexity of TPS.

The remainder of this chapter presents the detailed analysis.

Table 1-5. Types of Improvements

Section	Objective of Improvement
RF Functions (Section B)	
1. Instrument Frequency	Introductory section: No improvement discussed
2. RF Stimulus	
a. Maximum Output Power	Relieving the maximum power shortfall listed in Table 1-4
b. Minimum Power	Relieving a shortfall identified using the ECAC data
c. Frequency	Taking advantage of new technology
3. Synthesizer Replacement	Taking advantage of new technology
4. RF Power Measurement	
a. Maximum Power	Relieving the maximum power shortfall listed in Table 1-4
b. Minimum Power	No improvement needed
c. Frequency	Taking advantage of new technology
5. Resistive Loads	
a. DC Loads	Relieving the maximum power shortfalls listed in Table 1-4
b. RF Loads	Relieving the maximum power shortfalls listed in Table 1-4
6. Noise Figure	Adding new functionality
7. Phase Noise	Adding new functionality
8. RF Interface	Improving operability
Analog Functions (Section C)	
1. Pulse and Waveform Generation	Relieving maximum voltage shortfalls listed in Table 1-4
2. Digital Multimeter Current Measurement	Relieving maximum current shortfalls listed in Table 1-4
Digital Functions (Section D)	Relieving maximum voltage and current shortfalls listed in Table 1-4

B. RF FUNCTIONS

1. Instrument Frequency

Table 1-6 describes the maximum frequency of existing CASS instruments for which this characteristic is an important parameter, along with the percentage of the systems in the ECAC database that could be tested by each instrument.

Table 1-6. CASS Instrument Frequency Capability

Instrument	Maximum Frequency	Percentage of Requirements Met
RF stimulus	40.0 GHz	100
Power Measurement	50.0[a] GHz	100
Microwave Transition Analyzer	26.5 GHz	99
Spectrum Analyzers	22.0 GHz	99
Spread Spectrum Modulators	335.0 MHz	44
Frequency Counter	200.0 MHz	33

[a] Factory configuration is 26.5 GHz.

The first four instruments in Table 1-6 meet the frequency requirements of almost all systems. Although the spread spectrum modulators show only a 44-percent coverage of *all* systems, they can cover most of the systems that rely on spread spectrum techniques for their operation. The frequency counter covers only 33 percent of the systems, but all of its functions can be performed by the microwave transition analyzer or the spectrum analyzers. We conclude that CASS instrumentation has sufficient frequency response to meet almost all test requirements.

Recommendation: No action required.

2. RF Stimulus

CASS has three primary sources of RF stimulus, which are described in Table 1-7. These sources provide coverage from 10 MHz to 40 GHz. [The CASS Arbitrary Waveform Generators (AWGs) provide stimulus in the below-RF range (0.01 Hz to 25 MHz)]. The following sections analyze the ability of these RF sources to meet the requirements for frequency and output power. Replacing the current 20 GHz and 40 GHz RF synthesizers with new designs that offer significant size reductions was also examined.

Table 1-7. CASS RF Stimulus

Instrument	Frequency Minimum	Frequency Maximum	Output Power (dBm) Minimum	Output Power (dBm) Maximum
Comstron Signal Generators	10 MHz	18.4 GHz	-100	10
Frequency Synthesizer	10 MHz	2.3 GHz	-100	8.3
	2.3 GHz	40 GHz	-100	-6.4
High Power Synthesizer	3 GHz	18 GHz	-100	16.5
	18 GHz	20 GHz	-100	16

a. Maximum Output Power

The figures in Table 1-3 show that the maximum RF stimulus output of CASS (16.5 dBm) meets requirements for only 14 programs (35 applications less 21 exceptions) of the 35 programs for which the SSM has data.

Table 1-8 lists the frequency and power test requirements for the 21 exceptions, sorted by maximum power level. In this table and similar ones to follow, the requirements data are followed by five columns that present information on the populations and remaining lifetimes of the systems. As described earlier, these factors should enter into decisions regarding which improvements to make. (Criticality should also be taken into account, but evaluating it is beyond the scope of the study.)

1. The "Population" column lists the number of systems (blank if unknown).
2. The "Lifetime" column contains a "Y" (for "Yes") if the system has a remaining lifetime of 10 years or more (a blank means the information is unknown).
3. The "CIP" column contains a "Y" if the CASS (Aviation Support Equipment) Program Office has included the system in the CASS Implementation Plan (CIP). A "Y" reflects an implicit judgment by the Program Office that the system is worthy of testing by CASS by virtue of its population and lifetime (and perhaps even criticality).
4. A "Y" in the "CASS Candidate" column reflects our judgment that the system is worth considering for CASS support. Our criteria, which are somewhat broader than the criteria the Program Office used for including the system in the CIP, are the following:
   a. The system is designated for CASS support by the Program Office (i.e., there is a "Y" in the "CIP" column), *or*
   b. There is no "Y" in the "CIP" column, but the system's population is greater than 100 *and* its remaining life is greater than 10 years.

Table 1-8. Requirements of RF Stimuli Maximum Output Not Covered

System	Service	Requirements: Maximum Power (dBm)	Requirements: Frequency (GHz)	Population	Lifetime	CIP[a]	CASS Candidate	Relevant Population
AN/SLQ-32	Navy Ship	5	26	377	Y		Y	377
AN/USC-38	Navy Ship	8	46	300	Y		Y	300
F-14 (APG-71)	Navy Aircraft	12	26	56	Y	Y	Y	56
RF/Audio Amplifier	Navy Aircraft	20	18					
AN/ARN-138, (SRA)	Navy Aircraft	20	16					
AN/ARN-138, (WRA)	Navy Aircraft	20	16					
Offload Vast, S3 (SRA)	Navy Aircraft	23	0.4	115	Y	Y	Y	115
Offload APM-446, RSTS	Navy Aircraft	23	0.5			Y	Y	
Offload Vast, S3 (WRA)	Navy Aircraft	24	15	115	Y	Y	Y	115
High Power ATE	Navy Aircraft	30	10			Y	Y	
HFRG (URC-131)	Navy Ship	31.2	0.03		Y			
MRC-142	Marine Corps Ground	33	1.9	500	Y		Y	500
AN/ALR-67	Navy Aircraft	34	5.2	701	Y	Y	Y	701
SINCGARS	Marine Corps Ground	36	0.09	23,000	Y		Y	23,000
RT WRA	Navy Aircraft	40	14					
AN/ALQ-149	Navy Aircraft	42	0.1	152		Y	Y	152
EA-6B	Navy/Marine Corps Aircraft	42	20	152	Y	Y	Y	152
AN/APG-73	Navy Aircraft	50	18	534	Y	Y	Y	534
CEC	Navy Ship	53	8		Y	Y	Y	unknown
KC-130T	Marine Corps Aircraft	70.3	16	22	Y	Y	Y	22
AN/APS-137	Navy Aircraft	87	11	16	Y	Y	Y	16
Total								25,888

[a] CASS Implemenation Plan

5. The "Relevant Population" column lists the population of those systems (from the "Population" column) that are marked as CASS Candidates by the previous column.

In discussing the various CASS improvements, we refer to the "Relevant Population" as a general indicator of the value of an improvement. The data in Table 1-8, for example, indicate that if the output of the CASS RF stimulus were increased to the 36 dBm level required by SINCGARS, CASS would then be able to test the 23,000 SINCGARS radios (and all systems with lower power requirements, provided the frequency requirement was also met). Further increasing the power to 42 dBm would bring 152 EA-6Bs within CASS capability. Deciding where to stop would obviously require information on criticality, which we lack.

Turning now to the discussion of the requirements, the data in Table 1-8 indicate that testing some of the systems requires power levels above 50 dBm. Some of these systems are final amplifiers for transmitters. A CASS capability of 50 dBm could cover almost all requirements. Courses of action to reduce the RF stimulus shortfall include the following:

- Add a microwave broadband amplifier to boost the power level of existing RF stimuli.
- Replace one of the RF high power synthesizers with a unit capable of producing higher output levels.
- Add capability to TPS IDs.

Table 1-9 lists the features and price of several COTS microwave broadband amplifiers whose use would increase the power levels currently available in CASS. Option 4 covers almost all of the units shown in Table 1-8, and does it for the lowest price ($2,095). The last amplifier, Option 7, offers a much higher output of 50 dBm, but it covers only 152 units more than Option 4 and costs almost $15,000 more.

Table 1-9. Candidate Microwave Broad Band Amplifiers

Option	Wattage	Power (dBm)	Frequency Low	Frequency High	Price	Relevant Population
1	.01	10	45 MHz	50 GHz	$14,900	677
2	.06	18	2 GHz	50 GHz	$20,850	733
3	1	30	2 GHz	26.5 GHz	$18,900	663
4	4	36	.5 MHz	1 GHz	$2,095	23,115
5	10	40	1 MHz	1 GHz	$6,695	23,115
6	50	47	.2 GHz	1 GHz	$14,990	23,267
7	100	50	.5 GHz	1 GHz	$16,990	23,267

Replacing one of the existing CASS RF High Power Synthesizers is not a good option. The current CASS Synthesizer is a state-of-the-art instrument whose output level of 16.5 dBm is near the maximum output available from current commercial instruments.

The final option is to meet the needs of UUTs that require high-output RF stimulus by incorporating an active element such as an exciter or pre-amplifier into the ID of their TPSs. This option creates the familiar problems with active IDs—poor configuration control and documentation—resulting in operational problems for the maintainers who must use the ID. Option 4 in Table 1-9 thus appears to be the best alternative.

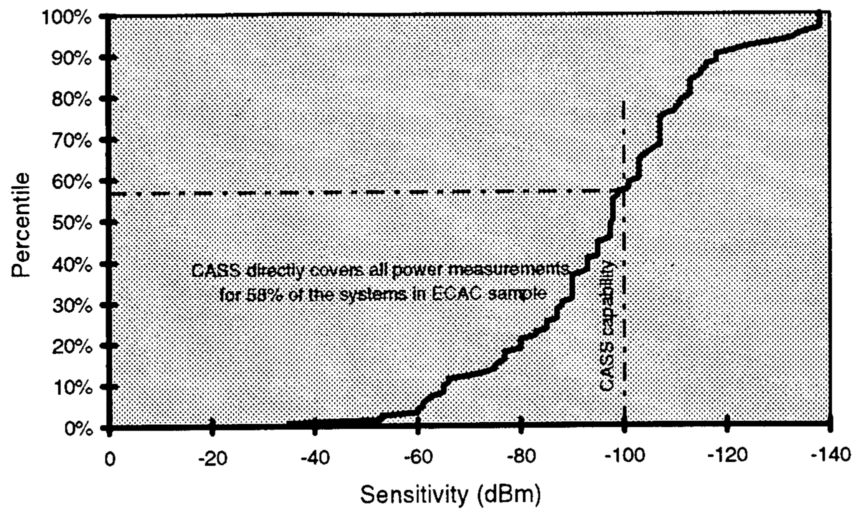
Recommendation: In the near term, add active elements to Interface Devices. In the far term, provide RF and CNI stations with a broadband amplifier with characteristics similar to those of Option 4.

b. Minimum Power

RF stimuli must be able to generate small signal levels in order to test the sensitivity of receivers. Table 1-3 showed that the minimum RF power output of CASS, -100 dBm, covers 32 of the 36 requirements (88.9 percent) in the SSM database. Table 1-10 lists the four exceptions. However, the data presented in Figure 1-1 indicate that the current CASS capability of -100 dBm covers only 58 percent of the total range of ECAC requirements, which range down to -138 dBm.

Table 1-10. RF Power Requirements Not Covered by CASS

System	Minimum Power Level (dBm)	Population
AN/APG-73	-101	534
KC-139T	-102	22
HFRG	-109	40
HSFB	-125	unknown



Note: 123 systems examined for NAVAIR, NAVSEA, Air Force, and Marine Corps Ground.

Figure 1-1. Receiver Sensitivity Versus CASS Capability to Cover ECAC Requirements

The shortfall could be relieved by adding a programmable attenuator that operates from DC to 40 GHz and provides attenuation up to 70 dB in 10 dB steps. The HP 84907L is a COTS example that costs $2,500.

Recommendation: Add a COTS programmable attenuator to all RF and CNI stations.

c. Frequency

The envelope analysis described in Chapter II indicates that the test envelope of only one program in the SSM database, the NAVSEA AN/USC-38 satellite communications terminal, falls outside of the RF stimulus frequency range of CASS. This terminal requires an uplink frequency of 43.5–45.5 GHz. CASS meets the RF stimulus requirements for all systems in the ECAC database. Given this high coverage, improving the CASS station's frequency capability does not appear justified. Requirements above 40 GHz, such as for the AN/USC-38, should be handled on a case-by-case basis (see Table 1-8, Option 4). Should increasing current frequency capability appear desirable in the future, it could be done in any of the ways listed in Table 1-11. The first three options are frequency multipliers that would be attached externally and driven by the existing CASS stimulus sources.

Table 1-11. Options for Increasing CASS RF Stimulus Frequency

Option	Unit Price
1. Add units to extend the maximum range from the current 40 to 60 GHz	$11,750
2. Add units to extend the maximum range from the current 40 to 75 GHz	$28,050
3. Add units to extend the maximum range from the current 40 to 110 GHz	$44,350
4. Equip systems requiring over 40 GHz with their own RF source in an active Interface Device	-

Recommendation: No short-term improvement is needed. To meet future needs, authorize CASS sites, on a case-by-case basis, to purchase one of the three external COTS devices listed in Table 1-11, or authorize TPS developers to put active elements in the Interface Devices (option 4).

3. Synthesizer Replacement

Replacing the current 20 GHz and 40 GHz Synthesizers now contained in CASS would have definite benefits. The current instruments are designed according to commercial standards, which make little provision for operating in harsh operating environments. The manufacturer of these units is developing RF synthesizers with comparable electrical characteristics that use the more rugged Modular Measurement System (MMS) architecture. The new instruments are also 50 percent smaller, so that replacing the two current synthesizers with the new models would free up space in the RF rack. This space could be used for new instruments or test accessories to provide functionality that CASS now lacks, such as phase noise measurement and attenuators.

Although the new synthesizers are scheduled to become available in the fall of 1996, the manufacturer has informed us that the schedule could be advanced if a firm requirement developed. Our information is that the new units will be comparable to the present synthesizers. The items are COTS, so that no development cost would be required beyond that of integrating and modifying the station software. Retrofitting CASS stations that are already deployed is not critical, since the fielded synthesizers appear to be operating satisfactorily.

These new units do lack the analog frequency sweep available in the fielded synthesizers. The sweep feature is most often used in conjunction with vector network analyzers. Since CASS does not contain network analyzers, the sweep feature is not currently needed. Moreover, even if the existing synthesizers were replaced with the new models and the sweep feature became needed, it could be provided by using the CASS

Atlas sweep command to perform the frequency sweep digitally. Some software modification would be needed.

Recommendation: Incorporate the new synthesizers into new CASS production units, and consider the option of retrofitting fielded units.

4. Power Measurement

The ability of an instrument to test the RF power output of a UUT depends on three important characteristics: its maximum power, minimum power, and frequency. Maximum power, for which CASS can cover only 58.1 percent of current requirements (Table 1-3), will be analyzed first. Minimum power will be discussed next. Although the data in Table 1-3 indicate that frequency is not a problem for CASS power measurement at present, we will discuss it here because current trends suggest that increasing frequency may become a problem in the future. Frequency will be considered as a peripheral issue in the discussion of maximum power, and will be discussed in its own right following the analysis of minimum power.

CASS can measure RF power with any of the instruments described in Table 1-12. The discussion of upgrades will focus on the Power Meter that can measure RF Power up to 44 dBm, far higher than the other instruments.

Table 1-12. CASS RF Power Instruments

	Power Level (dBm)		Frequency Range	
Instrument	Minimum	Maximum	Minimum	Maximum
Power Meter	-30	+20	50 GHz	100 KHz
	-30	+44	18 GHz	100 KHz
Microwave Transition Analyzer	-60	+.01	26.5 GHz	0.1 Hz
Spectrum Analyzer	-140	+20	22 GHz	100 Hz

a. Maximum Power

In an RF power meter, the RF signal to be measured is passed to a primary circuit, or sensor, that includes a resistor whose resistance depends on the RF current flow in a known way. A secondary circuit, by measuring the current, calculates the resistance and thus, given the other characteristics of the circuit, the applied power.

One sensor cannot be used for all situations, however. Because of the sensitivity and imbedded capacitances and inductances in the primary circuit, the current is a function of frequency, as well as resistance. This eliminates the one-to-one relationship between resistance and input power, and creates a need for using different sensors, with different sensitivities, in different frequency ranges. Different sensors are also needed in different power ranges to accommodate the joint requirements of sensitivity and heat dissipation.

As a result of these complications, Power Meters are used in conjunction with a set of sensors. The larger the set, the greater the range of capability. Table 1-13 lists the sensors that are currently shipped with the CASS Power Meter, the HP 70100A. With these sensors, the CASS Power Meter can measure the combinations of power and frequency shown in Figure 1-2 in the area marked Factory Sensor Coverage. The dots represent the requirements of various systems. (Some dots are overlays of several systems.)

Table 1-13. Sensors Shipped With CASS

Sensor[a]	Power	Frequency
HP 8482A	-30 to 20 dBm	100 KHz to 4.2 GHz
HP 8485A	-30 to 20 dBm	50 MHz to 26.5 GHz
HP 8481D	-70 to -20 dBm	10 MHz to 18 GHz
HP 8485D	-70 to -20 dBm	50 MHz to 26.5 GHz

[a] Hewlett Packard instruments are shown for illustration only.

Note that many requirements are not covered. CASS capability can be extended at fairly low cost, however, by equipping CASS with the additional sensors shown in Table 1-14. Sensors HP 8481B and HP 8482B can increase CASS maximum power measurement capability to +44 dBm, depending on frequency. To meet the SSM test requirements, the HP 8481B, which provides frequency coverage of the 10 MHz to 18 GHz, is the recommended choice. Sensor HP 8487A extends CASS power measurement capability to 50 Ghz, but at a maximum power level of only +20 dBm. Because there are only a relatively few test requirements above the 26.5 Ghz now covered by CASS, this sensor should be procured only on a case-by-case basis.

Table 1-14. Additional Sensors To Increase the Capability of the CASS Power Meter

Sensor[a]	Power Level	Frequency Range	Cost
HP 8481B	0 to 44 dBm	10 MHz to 18 GHz	$810
HP 8482B	0 to 44 dBm	100 KHz to 4.2 GHz	$810
HP 8487A	-30 to 20 dBm	50 Mhz to 50 Ghz	$2,595

[a] Hewlett Packard instruments are shown for illustration only.

These sensors would increase CASS power and frequency to the area shown by the dotted lines in Figure 1-2. The plot shows that the requirements for 18 of the systems are still not covered. These systems are shown in Table 1-15. These findings on CASS power and frequency capability, which have been derived using the SSM database, are supported as well by the ECAC data in Figure 1-3. Even with the additional sensors, the CASS Power Meter would cover only 60 percent of the ECAC requirements.

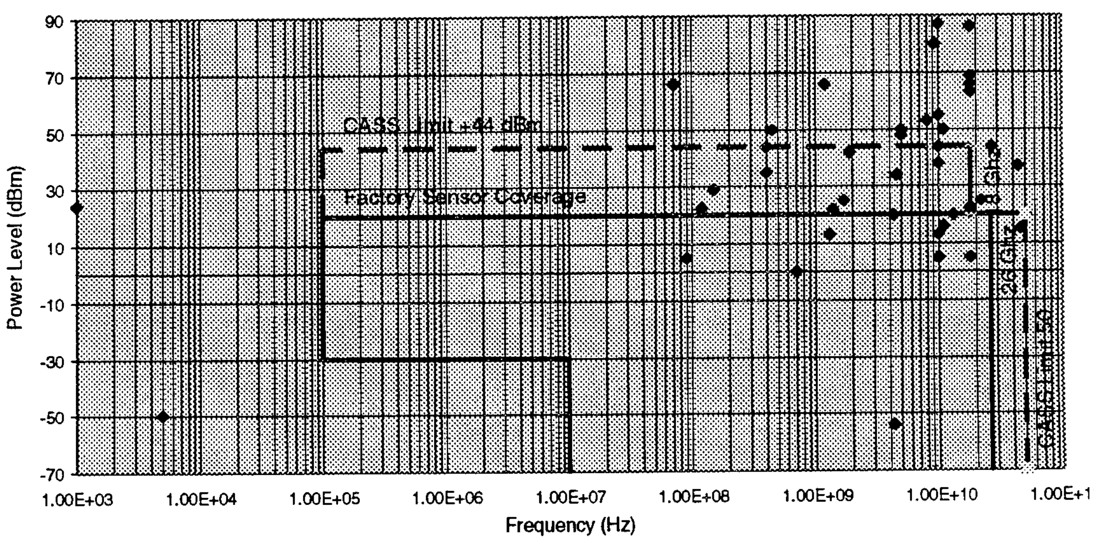
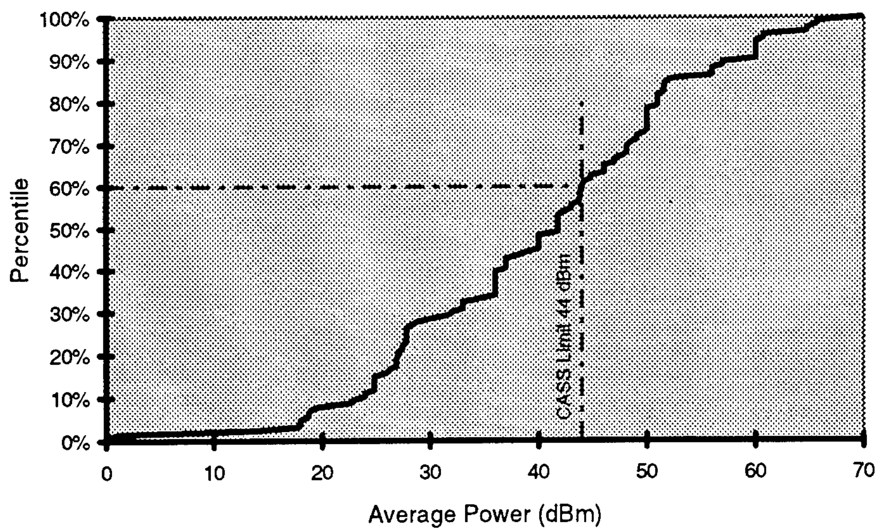


Figure 1-2. RF Power Measurement

Some additional improvement in coverage is clearly desirable. [Covering the top requirements near 90 dBm would be inefficient, however. It would be costly to upgrade hundreds of CASS stations to satisfy the needs of only 22 systems (plus the needs of two additional systems whose populations are unknown). It would be better to rely on existing special-purpose testers.]

Table 1-15. Requirements for RF Power Measurement Not Currently Met

System	Service	Requirements: Maximum Power (dBm)	Requirements: Frequency (GHz)	Population	Lifetime	CIP	CASS Candidate	Relevant Population
EA-6B	Marine Corps Aircraft	25	22	152	Y	Y	Y	152
SCAMP	Marine Corps Ground	37	44	100	Y		Y	100
AN/SLQ-32	Navy Ships	44	27	377	Y		Y	377
SINCGARS	Marine Corps Ground	48	5	23,000	Y		Y	23,000
AN/TSQ-129	Marine Corps Ground	50	0.5	1,677	Y		Y	1,677
S-3 Offload	Navy Aircraft	50	11	115	Y	Y	Y	115
AN/TRC-170	Marine Corps Aircraft	50	5	100	Y		Y	100
CEC	Navy Ships	53	8		Y	Y	Y	
AN/ASW-9 WRA	Navy Aircraft	55	10	373				
HFRG	Navy Ships	66	0.007	40	Y			
RT WRAH-	Navy Aircraft	66	18		Y			
AH-1W	Marine Corps Aircraft	66	18	161	Y	Y	Y	161
MV-22	Marine Corps Aircraft	66	18	552	Y	Y	Y	552
UH-1N	Marine Corps Aircraft	66	1.2	148	Y	Y	Y	148
KC-130T	Marine Corps Aircraft	80	9.4	22	Y	Y	Y	22
RF/Audio Amplifier	Navy Aircraft	86	18		Y			
High Power ATE	Navy Aircraft	87	10		Y	Y	Y	



Note: CASS covers all power measurements for 60% of systems without attenuation.

Figure 1-3. Average Power Versus CASS (Using ECAC Data)

CASS capability for power measurement could be upgraded either by adding either an attenuator or a directional coupler. An attenuator would convert a portion of the power into heat, thus lowering the RF energy to a level that could be measured with the Power Meter. A directional coupler would select a sample of the total power flowing through the device, measure the power of the sample, and extrapolate the result to estimate the total power level. Table 1-16 lists the characteristics of several COTS attenuators and directional couplers.

Table 1-16. Instruments for Upgrading the Maximum Power Capability of CASS Power Measurement

Device	Type of Device	Power	Frequency	Attenuation	Unit Cost	Number Served
DC 6000	Directional Couplers	62 dBm	.4 to 1 GHz	50 dB	$675	1,677
50FN030-300	Attenuator	55 dBm	DC to 1 GHz	30 dB	$600	1,677
48-20-43	Attenuator	50 dBm	DC to 18 GHz	20 dB	$480	24,892

The second attenuator listed in Table 1-16 is an attractive alternative. It is a low-cost COTS instrument that would satisfy a large number of shortfalls and could be added as an accessory with no integration cost.

Recommendation: Install a sensor to extend power measurement to 44 dBm. Consider adding a directional coupler or attenuator to extend measurement further, to 50 dBm.

b. Minimum Power

Frequency might also be a future problem for minimum power measurement. Although the current CASS Spectrum Analyzer can measure power down to -140 dBm, which is fully sufficient to meet the lowest UUT requirement of -53 dBm, the Spectrum Analyzer's frequency limit of 22 GHz might not be high enough to meet the frequencies implied by future trends in technology.

Recommendation: No immediate action is needed.

c. Frequency

The figures in Table 1-3 indicate that upgrading the power measurement frequency range of CASS is not a pressing concern at present. Should higher frequency response become needed in the future, CASS capability could be upgraded by providing the CASS Power Meter with the additional sensor shown in Table 1-17.

Table 1-17. External Sensor for Upgrading the Frequency Capability of CASS Power Measurement

Sensor[a]	Power	Frequency	Price
HP W8486A	-30 to 20 dBm	75 GHz to 110 GHz	$6,200

[a] Hewlett Packard instrument is shown for illustration only.

Another possibility would be to upgrade the capability of the Spectrum Analyzer (which can measure power up to 20 dBm at frequencies up to 22 GHz) by equipping it with a set of external millimeter mixers. The Spectrum Analyzer has an interface to which such a mixer could be attached. Table 1-18 lists two sets of commercially available mixers. The HP 11974 series would support automated testing and simplify TPS development. Both instrument series are COTS, so there is no development cost.

Table 1-18. External Mixers for the CASS Spectrum Analyzer

Millimeter Mixers[a]	Frequency	Number of Models	Cost
HP 11974 Series	26.5 to 75 GHz	4	$17,350
HP 11970 Series	18 to 110 GHz	6	$2,245-$3,470

[a] Hewlett Packard instruments are shown for illustration only.

Table 1-19 is a summary of the options.

Table 1-19. Options for RF Power Measurement

Option	Unit Cost	Commercial Availability	Interface
1. Add a power sensor to extend the range of the CASS power meter to +44 dBm	$810-$2,595	COTS	None
2. Add an attenuator capable of 20-30 dB attenuation at power levels up to 50 dBm	$480	COTS	Limited

Recommendation: No immediate action is required. For the future, authorize individual CASS sites to acquire, when needed, external COTS units (sensors, mixers, or attenuators) to extend the frequency of the power meter and the spectrum analyzer.

5. Resistive Loads

This section discusses, among other topics, improvements to relieve the shortfall regarding Resistive Loads, Maximum Power, listed in Table 1-4.

a. DC Loads

The CASS station has resistive loads that are primarily used to test UUT power supplies. These resistors can be added in series and parallel to meet a range of resistance and power handling requirements. However, Figure 1-4 shows that CASS cannot provide the combination of resistance and power required by many systems.

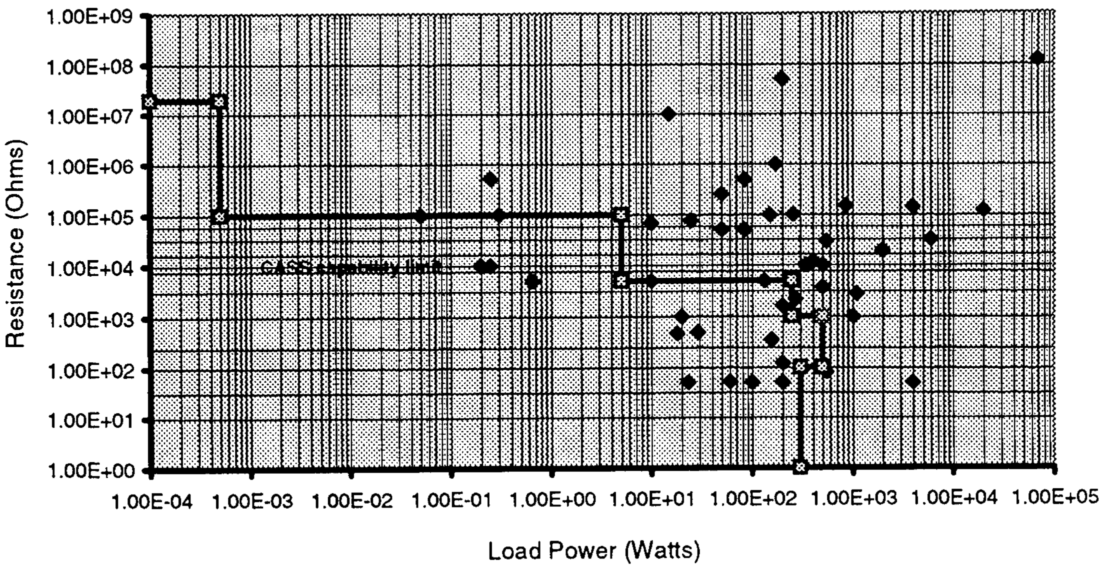


Figure 1-4. Resistive Load Requirements

Table 1-20 lists the test requirements for power and resistance that fall outside CASS capability. The resulting voltages, determined from the relationships V=IR and $P=I^2R$, are also shown for later discussion. The figures above the horizontal line list the requirements that are not met because, while they are under the separate CASS limits of 600 watts and 5,000 volts, they nevertheless involve *combinations* of wattage and voltage that are beyond current CASS capability. These requirements could be easily met by providing CASS with an additional variable resistor, plus a new switching assembly that the resistor would require. Table 1-21 lists 7 variable resistors that could be used. The R-3 resistor yields the largest benefit; it would relieve 6 test shortfalls affecting approximately 24,000 systems. The cost of the switching assembly plus the R-3 would be approximately $540,000 for development (R-3 is not COTS) and $11,000 per unit for procurement.

CASS cannot handle the requirements that involve high powers and resistances (those below the horizontal line in Table 1-20), because of the need for high heat dissipation and voltage isolation. These requirements pertain to a small population of systems, however, so that the simplest way to accommodate them is for TPS developers to add loads to the Interface Devices of the affected UUTs.

Recommendation: Allow TPS developers to meet unique resistive load requirements by adding active elements to Interface Devices.

Table 1-20. Requirements for DC Resistive Loads Not Currently Met

System	Service	Requirement			Population	Lifetime	CIP	CASS	Relevant
		Watts	Ohms	Volts				Candidate	Population
AN/AWG-9 WRA	Navy Aircraft	0.25	510,000	357	393				
F-14D Radar SRA	Navy Aircraft	10	69,000	831	56	Y	Y	Y	56
F/A-18 E/F	Navy/Marine Corps Aircraft	25	75,000	1,369	163	Y	Y	Y	163
USM-470 OFLD WRA	Navy Aircraft	50	50,000	1,581			Y	Y	
USM-470 OFLD SRA	Navy Aircraft	50	250,000	3,536			Y	Y	
AV-8B	Marine Corps Aircraft	84	50,000	2,049	255	Y	Y	Y	255
SINCGARS	Marine Corps Ground	150	100,000	3,873	23,000	Y		Y	23,000
AN/SQQ-89	Navy Ship	270	2,200	771	343	Y	Y	Y	343
F-14D WRA	Navy Aircraft	342	10,000	1,849	56	Y	Y	Y	56
Avionics RF/Audio Amplifier	Navy Aircraft	400	12,000	2,191					
S-3 WRA	Navy Aircraft	500	3,750	1,369	115	Y		Y	115
F-14D OFLD VAST WRA	Navy Aircraft	500	10,000	2,236	56	Y			
AN/ALQ-165	Navy/Marine Corps Aircraft	545	80	209	311	Y	Y	Y	311
F/A-18 C/D	Navy/Marine Corps Aircraft	545	30,000	4,044	534	Y	Y	Y	534
F-14D OFLD VAST SRA	Navy Aircraft	15	10 M	12,247	56	Y	Y	Y	56
AV-8B EETS/HTS WRA	Navy/Marine Corps Aircraft	84	500,000	6,481	255	Y	Y	Y	255
S-3 HATS	Navy Aircraft	170	1 M	13,038	115	Y	Y	Y	115
AV-8B EETS/HTS SRA	Navy/Marine Corps Aircraft	200	50 M	100,000	255	Y	Y	Y	255
MK-78	Navy Ship	256	100,000	5,060		Y			
AN/APQ-73	Navy Aircraft	860	15,000	11,358			Y	Y	
S-3 VAST OFLD SRA	Navy Aircraft	1,000	1,000	1,000	115	Y	Y	Y	115
AN/APS-137	Navy Aircraft	1,100	2,800	1,755	16		Y	Y	16
Avionics RT WRA	Navy Aircraft	2,000	20,000	6,325					
ANURC-131	Navy Ship	4,000	50	447	40	Y			40
High Power ATE SRA	Navy Aircraft	4,000	140,000	23,664				Y	
S-3 VAST OFLD WRA	Navy Aircraft	6,000	33,000	14,071	115	Y	Y	Y	115
Power Supply	Navy Aircraftcraft	20,000	120,000	48,990					
High Power ATE WRA	Navy Aircraft	70,000	120 M	> 2 M			Y	Y	

Table 1-21. Candidate DC Resistive Loads

Candidate Resistors	System	Service	Capability Watts	Capability Ohms	Requirement Watts	Requirement Ohms	Volts	Population
R-1	R-1 Capability		1	600,000			775	
	AN/AWG-9 WRA	Navy Aircraft			0.25	510,000	357	393
							Total	**393**
R-2			50	250,000			3,535	
	USM-470 OFLD SRA	Navy Aircraft			50	250,000	3,536	
							Total	**Unknown**
R-3			150	100,000			3,873	
	F-14D Radar SRA	Navy Aircraft			10	69,000	831	56
	F/A-18 E/F	Navy/Marine Corps Aircraft			25	75,000	1,369	163
	USM-470 OFLD WRA	Navy Aircraft			50	50,000	1,581	
	AV-8B	Marine Corps Aircraft			84	50,000	2,049	255
	SINCGARS	Marine Corps Ground			150	100,000	3,873	23,000
							Total	**23,474**
R-4			600	30,000			4,243	
	F/A-18C/D	Navy/Marine Corps Aircraft			545	30,000	4,044	534
							Total	**534**
R-5			500	15,000			2,739	
	F-14D WRA	Navy Aircraft			342	10,000	1,849	56
	Avionics RF/Audio Amplifier	Navy Aircraft			400	12,000	2,191	
	F-14D OFLD VAST WRA	Navy Aircraft			500	10,000	2,236	56
							Total	**112**
R-6			500	5,000			1,581	
	AN/SQQ-89	Navy Ships			270	2,200	771	120
	S-3 WRA	Navy Aircraft			500	3,750	1,369	115
							Total	**235**
R-7			600	100			245	
	AN/ALQ-165	Navy/Marine Corps Aircraft			545	80	209	311
							Total	**311**

b. RF Loads

RF loads are used to terminate the outputs of power transmitters and other producers of RF power in order to simulate operational conditions during test. Approximately 95 percent of the requirements for RF loads could be met with the loads described in Table 1-22. These characteristics are a composite drawn from the SSM and ECAC databases, and from inputs provided by the Naval Surface Weapons Center at Crane, IN.

Table 1-23 describes several COTS devices that would cover the characteristics in Table 1-22 (with the exception that the frequency range of 2.5-3.95 GHz is missing).

Table 1-24 lists the options. The $15,200 unit cost of the second option is the total cost of $4,840 from Table 1-23 plus additional costs of forming the loads into a mobile RF auxiliary rack.

In summary, it is clear that CASS needs additional RF loads. Option 1 is a limited solution because it provides 60 dBm power up to a maximum frequency of 2.5 GHz. Option 2 is more robust—providing power up to 66 dBm up to a frequency of 18 GHz—but it costs much more. The ultimate choice between these two options is not clear.

> Recommendation: Acquire several RF loads that meet the requirements shown in Table 1-22

Table 1-22. Requirements for RF Resistive Loads

Frequency	3 MHz to 18 GHz
Average Power	4KW (66 dBm)
Peak Power	100KW (80 dBm)
Impedance	50 ohms

Table 1-23. Candidate RF Resistive Loads

Device[a]	Frequency Range	Power Watts (dBm)	Price
Bird 8833-300	DC-2.5 GHz	1,000 (60)	$895
JFW Industry -388	3.95-5.85 GHz	4,000 (66)	1,200
JFW Industry -588	5.85-8.20 GHz	4,000 (66)	945
JFW Industry -688	8.20-12.4 GHz	1,000 (60)	870
JFW Industry -788	12.4-18.0 GHz	500 (57)	930
		Total	$4,840

[a] These devices, from Bird Electronic Waveline, Inc. and JFW Industries, are shown for illustration only.

Table 1-24. Options for Resistive Loads

Alternative	Cost: Development	Cost: Unit Procurement
1. Incorporate the DC to 2.5 GHz 1,000-watt load into the CASS RF Rack and incorporate other load requirements into the system UUT test set-up as required.	None (COTS)	$895
2. Incorporate the full set of loads into an RF Load Auxiliary Unit.	$ 760,000[a]	$15,200[a]

[a] Preliminary estimate.

6. RF Noise Figure

RF noise is present in all electronic devices due to the random movement of electrons. The various effects are called impulse noise, quantizing noise in digital systems, shot noise in transistors, and thermal noise in resistors. Noise degrades the performance of electronic systems and is the limiting factor in systems such as radar receivers that deal with low signal levels. The RF noise figure of a device is defined as the reduction in the signal-to-noise ratio between input and output. It is calculated by comparing the output power level of the device when an external, calibrated noise source is input, with the output power level when the noise source is removed. The input and output power levels are inserted into a formula to calculate the degradation of the signal-to-noise ratio.

CASS does not have a noise figure meter at present. It cannot, therefore, meet the range of ECAC test requirements for the (low) RF noise figures shown in Table A-2 (Appendix A). For the 52 systems for which there are data on noise figure, these requirements range from 1.9 to 20 dB in power and 300 MHz to 18 GHz in frequency.

With some small changes, however, CASS could measure noise figure to an accuracy of ±0.71 dB using its calibrated noise source in conjunction with its local oscillator and spectrum analyzer. This method would require adding a small amount of cabling and switching to the RF rack, plus making some minor modifications in station software to perform the calculation mentioned above. These hardware and software modifications would have a procurement cost of $3,000 per station and a recurring software license cost of $2,000 per station.

This appears to be an attractive option, given the relatively low cost and the fact that almost 30 percent of the systems in the ECAC database require a test for RF noise figure.

Recommendation: Activate the Noise Figure elements contained in CASS.

7. Phase Noise

Phase noise is the random variation in the phase or frequency of electronic signals. Such variations degrade the operation of systems such as Doppler radars, which measure shifts in the frequency of reflected echoes in order to pick out moving ground targets and measure the speeds of opposing aircraft.

Phase noise is defined by the power density (in watts per Hz) at one or more offset frequencies around the central carrier frequency, expressed as a ratio of the power density in the carrier itself. (The goal is obviously to have small phase noise.) The power densities at various offsets around the carrier are measured by creating beat frequencies (heterodyne components), either by mixing the signal emitted by the UUT with the signal produced by a local oscillator, or by using a delay line and mixer to compare the UUT signal with itself displaced in time. The power densities in the beat frequencies and the carrier are then measured by a spectrum analyzer.

Neither the SSM nor the ECAC databases list the phase noise requirements of the systems. Table 1-25 repeats figures gathered in the earlier IDA study (Reference 1) for the ATARS communications system and an X-band radar. The first row, for example, indicates that the ATARS requires that the power density at a 200 Hz offset from a 10 MHz carrier be at least 66 dBc down from the power density in the carrier ($10^{-6.6} \times$ the power of the carrier frequency).

Table 1-25. A Sample of Phase Noise Requirements

System	Carrier	Offset	Sensitivity
ATARS	10 MHz	200 Hz	-66 dBc
	10 MHz	1 MHz	-133 dBc
X-band radar	10 GHz	3 KHz	-130 dBc

CASS has only limited capability to meet these requirements at present. The local oscillator and spectrum analyzer can be used to generate beat frequencies from the UUT (the first method mentioned above) in order to measure sensitivity down to -80 dBc at carrier frequencies from 5 MHz to 22 GHz. The second method for measuring sensitivity described above cannot be used because CASS lacks a delay line. CASS can therefore meet the first ATARS requirement listed in Table 1-25, but the -80 dBc limit is far short of the sensitivity required for the 1 MHz offset or the X-band radar.

It would be better to evaluate the phase noise capability of CASS using more than three data points, but such data are not available, at least in the SSM and ECAC databases. We can, however, at least determine how many systems would be degraded by the presence of phase noise. We estimated this number by counting the number of systems that are described in any of the following ways in the ECAC database:

- They rely on detecting Doppler shifts.
- They detect speed.
- They transmit digital data (phase noise degrades the sharpness of digital waveforms).
- They use frequency-hopping modulation.

Fully 36 systems, (approximately 20 percent) of the ECAC sample of 181 systems, satisfy at least one of these criteria. The highest operating frequency represented in the sample is 18 GHz, which is within the CASS frequency limit of 22 GHz.

If further study shows that many of these systems require sensitivities greater than -80 dBc, that would suggest that the capability of CASS should be upgraded. If space is a problem, a phase noise tester could be installed in the RF rack in the space obtained by replacing the current two RF synthesizers, as we recommended earlier. COTS phase noise test sets that are designed using the MMS technology and able to use the current CASS local oscillator and spectrum analyzers are available. One of the commercial models can accommodate carrier frequencies from 5 MHz to 18 GHz and measure X-band phase noise floors down to -137 dBc at an offset of 1 MHz, which substantially exceeds the requirements listed in Table 1-25. A device with this frequency range and sensitivity could likely test the phase noise found in the oscillators of radar receivers, transmitter exciters, and electronic warfare systems.

Also available is a more sophisticated phase noise test set that can measure the phase noise found in high power amplifiers such as traveling wave tubes. (These are called "additive" phase noise test sets; the less sophisticated type are called "absolute" phase noise test sets.)

The phase noise test sets require the use of two local oscillators, similar in quality to the HP 70900B local oscillator now installed in CASS. If the CASS Program Office were to replace the two existing RF synthesizers as discussed earlier, one of the new synthesizers could be used as the second local oscillator

Table 1-26 lists the options and procurement costs for giving CASS the ability to measure phase noise.

Table 1-26. Options for Phase Noise Measurement

Alternatives	Procurement Costs
1. Absolute Phase Noise Test Set with Oscillator	$85,000
2. Absolute Plus Additive Phase Noise Test Set with Oscillator	$96,500
3. Absolute Phase Noise Test Set without Oscillator	$65,000
4. Absolute Plus Additive Phase Noise Test Set Without Oscillator	$76,500

Recommendation: Acquire a phase noise measurement capability.

8. RF Interface

The RF interface (RFI) located at the front of the RF and CNI racks is the place where RF connections are made between the CASS station and the UUT. The RFI is thus the intermediary between the cables that are connected to the UUT and the CASS RF instruments: the two power meters, the two RF synthesizers, the spectrum analyzer, the microwave transition analyzer (MTA), the special modulators, and the signal calibrators. The RFI also contains a noise source, three directional couplers, one power splitter, and two attenuator assemblies used to support RF testing.

The RFI also contains 29 coaxial switch relays which are controlled by the CASS computer and which operate over the frequency range of 5 MHz to 26.5 GHz. These relays are off-on switches that allow the CASS station to make the connections between the RFI input-output connectors and the instruments that are specified by the TPS. These relays, however, are all hard wired to specific instruments. Relays K1 and K2, for example, connect the power meter to the calibration source or to the power meter input jack on the RFI. This hard wiring limits the ability of CASS to configure the RF instruments to meet all UUT test needs.

At present, TPS developers can make up for this lack of flexibility by putting RF switches in the IDs. This creates problems for configuration control, calibration, and maintainer operations. Such problems could be avoided by installing either an RF Matrix Switch or a coax switch assembly (or multiport switch) in the station, behind the RFI. This would lead to simpler IDs and TPS software, and also aid the RF calibration process. Table 1-27 lists two possible options.

Table 1-27. RFI Switch Options

Option	Cost	
	Development	Unit Procurement
1. Add several COTS multiport coax switches	$470,000	$9,400[a]
2. Install a COTS microwave matrix switch	$150,000	35,500[a]

[a] Preliminary estimates

Option 1 is a coax switch assembly involving two 1x6 coax switches (the maximum HP configuration) connected back-to-back. This assembly would make it possible to connect any of the six inputs to any of the six outputs. Coax 1x6 microwave switches that operate over the wide frequency range from DC to 20 GHz are available.

The device in Option 2 is a 10x10 matrix device (10 inputs and 10 outputs), which allows any input to be connected to any output or collection of outputs. For example, the RF output of the UUT could be sent to one of the spectrum analyzers and to one of the power meters, while simultaneously sending the output of an RF synthesizer to the UUT and to the MTA.

The matrix switch would operate under RS–232 control over the range from DC to 25 GHz, and over power levels up to 30 dBm. The unit is designed to Military Standard (MilStd) 454 and has electromagnetic interference (EMI) packaging, so that additional ruggedization would not be required.

The introduction of more switching would clearly increase the flexibility of the CASS RF and CNI Systems, but it is not clear which alternative is better. Option 1 has a much lower unit procurement cost (and the lowest cost overall if at least 13 units are bought), but the matrix switch provides much more flexibility. The choice would depend on factors we have not studied, such as the need for flexibility, and technical issues regarding heat dissipation and electronic interference.

Recommendation: Sponsor a complete cost and technical analysis of more RF switching.

C. ANALOG FUNCTIONS

CASS uses a variety of instruments for testing analog functions: AC and DC power supplies, the digital multimeter (DMM), instruments for generating pulses and waveforms and measuring the responses of the UUT, instruments for measuring frequency and time intervals, and instruments for measuring complex waveforms. The earlier analysis of the SSM data presented in Table 1-3 indicates that with these instruments, CASS can

meet over 85 percent of analog test requirements except for the following (Table 1-28): maximum output voltage for pulse and waveform generation (for which CASS has 48.9 and 54.1 percent coverage, respectively), and maximum AC and DC current generation by the DMM (16.7 and 83.6 percent coverage, respectively). Because pulses and waveforms are similar (the first is discrete, the second continuous), they will be discussed together, as will AC and DC current measurement.

Table 1-28. CASS Coverage of Analog Test Characteristics

Characteristic	CASS Capability	Percentage of Requirements Met
Pulse Generation	Maximum output of 10 volts	48.9 %
Waveform Generation	Maximum output of 10 volts	54.1%
AC Current Measurement	Maximum current of 2 amps	16.7 %
DC Current Measurement	Maximum current of 20 amps	83.6%

1. Pulse and Waveform Generation

Pulses and waveforms that are used to test electronic systems are defined by three major parameters: voltage (the height of the pulse or waveform), maximum and minimum repetition rates (called frequency for waveforms), and pulse width.

Tables 1-29 and 1-30 show the system test requirements for pulse generation and waveform generation, respectively, that exceed the current CASS output limit of 10 volts. (The column marked Amplifier Coverage will be discussed later.) The requirements for repetition rate and frequency are also shown, although the analysis in Table 1-3 shows that CASS meets our criterion of 85 percent coverage for these requirements.

Figures 1-5 and 1-6 show that the requirements for output voltage, which extend to 70 and 150 volts for pulse generation and waveform generation respectively, lie far beyond the 10-volt capability of CASS.

We evaluated the following options to relieve the voltage shortfall:

1. Add an accessory (external) pulse amplifier, such as the one of the models identified in Table 1-31.

2. Modify the existing pulse and waveform instruments to increase output to 50 volts and 36 volts for the pulse instruments and waveform instruments, respectively. These improvements would enable CASS to cover almost all of the pulse requirements (all but 56 out of at least 2,000).

Table 1-29. Requirements for Analog Pulse Generation Not Currently Met

System	Repetition Period		Voltage	UUT Population	Amplifier Coverage	Lifetime	CIP	CASS Candidate	Relevant Population
	Maximum	Minimum							
High Power ATE (WRA)	.002	.00001	11				Y	Y	
High Power ATE (SRA)	.024	3.30E-6	12		Y		Y	Y	
EA-6B	.016	.0001	13	152		Y	Y	Y	152
EA-6B ASM-614 OFLD	.0001	.0001	13	152		Y	Y	Y	152
S-3 OFLD HATS	60	1.00E-8	15	115	Y	Y	Y	Y	115
AN/SLQ-32	0.95	2.00E-8	16	377	Y	Y		Y	377
F-14b OFLD TMV	.0017	3.20E-6	18	69	Y		Y	Y	69
AH-1W	5	1.00E-7	20	161	Y	Y	Y	Y	161
KC-130T	.005	.005	20	22		Y	Y	Y	22
F-14D Radar (SRA)	1.00E-07	1.00E-11	25	56	Y	Y	Y	Y	56
Avionics RF/Audio Amplifier	.01	.00054	25						
AN/AWG-9 (SRAs)	1	2.00E-6	25	373					
AV-8B EETS/HTS	0.4	.00006	27	255		Y	Y	Y	255
Avionics Computer/Video	.00001	1.00E-5	27						
AN/APN-151	1	.00051	27						
S-3 WRAs	30	1.30E-8	30	115	Y	Y	Y	Y	115
MV-22	50	1.00E-7	32	552	Y	Y	Y	Y	552
F-14D Radar (WRA)	30	3.2E-6	40	56		Y	Y	Y	56
F-14D APG-71	.004	1.00E-6	50	56		Y			
AN/APS-137	1	1.20E-7	50	16			Y	Y	16
Avionics Power Supplies	.001	.001	50						
Avionics RT WRAs	50	1.00E-7	60		Y				
F-14D OFLD VAST (SRA)	2	2.50E-6	70	56		Y	Y	Y	56

Table 1-30. Requirements for Analog Waveform Generation Not Currently Met

System	Frequency (Hz) Maximum	Frequency (Hz) Minimum	Voltage	UUT Population	Amplifier Coverage	Lifetime	CIP	CASS Candidate	Relevant Population
EA-6B	8.00E+7	8.00E+7	10.5	152	Y	Y	Y	Y	152
F-14D AN/APG-71	1.40E+6	1.40E+6	10.7	56	Y	Y			
AN/ALR-67 (v) 3/4	3,000	300	12	701		Y	Y	Y	701
Avionics OFLD USM-470 WRA	71,000	40	13.2				Y	Y	
A-6 IR Receiver	4,000	220	15	150					
AV-8B OFLD EETS/HTS	100,000	21	17.5	255		Y	Y	Y	255
AH-1W	1.00E+7	30	20	161	Y	Y	Y	Y	161
Avionics RF WRAs	2.00E+6	300	20		Y				
F/A-18 C/D	2.00E+7	40	21	634	Y	Y	Y	Y	634
AN/BQQ-5	8.70E+6	1.5	22	82	Y	Y			
Avionics OFLD SUM-470 SRA	26,000	60	24				Y	Y	
F-14D Radar SRAs	7.00E+10	25	25	56	Y	Y	Y	Y	56
KC-130T	50,000	20	26	22		Y	Y	Y	22
S-3 AAM-60 OFLD	900	900	26	115		Y	Y	Y	115
F-14D OFLD VAST WRA	2,000	420	26.5	56		Y			
F-14D OFLD VAST SRA			28	56		Y			
Avionics Computer/Video	200E+6	2,000	28		Y				
Avionics Pwr Supplies	46,000	430	28						
AV-8B	100,000	21	29	255		Y	Y	Y	255
MV-22	2.00E+7	0.66	29	552	Y	Y	Y	Y	552
F-14D OFLD VAST	2.50E+7	8	29	56	Y	Y	Y	Y.	56
AN/AWG-9 WRAs	3.00E+7	0.05	30	393	Y				
A-6 2W	4,000	30	32	150					
AN/APS-137 SRA	2.00E+8	2.00E+8	36	16		Y	Y	Y	16
F-14D IRST	400	400	50	56		Y	Y	Y	56
S-3 OFLD HATS	1.00E+6	400	100	115		Y	Y	Y	115
Avionics RF/Audio Amplifier	50,000	160	120						
AN/APS-137 WRA	2.70E+7	2.70E+7	150	16		Y	Y	Y	16
F-14D Radar WRAs	2.00E+7	2.00E+7	155	56	Y	Y	Y	Y	56

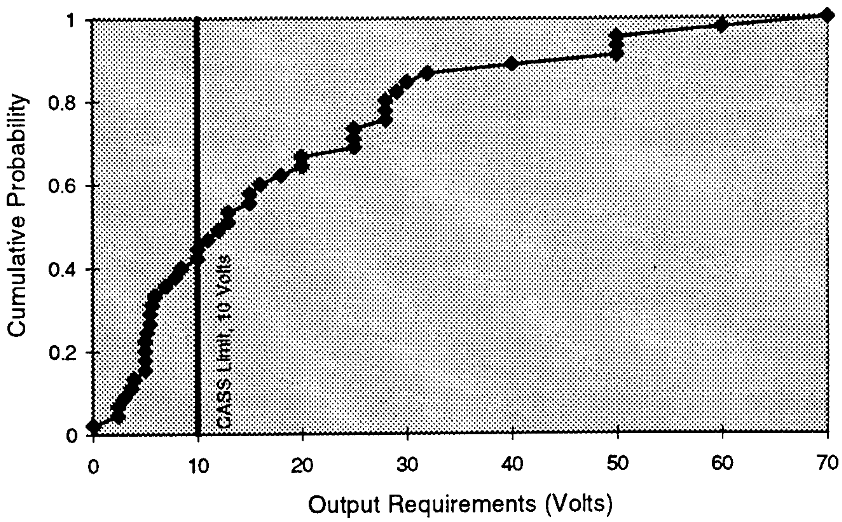


Figure 1-5. Pulse Generation, Output Voltage

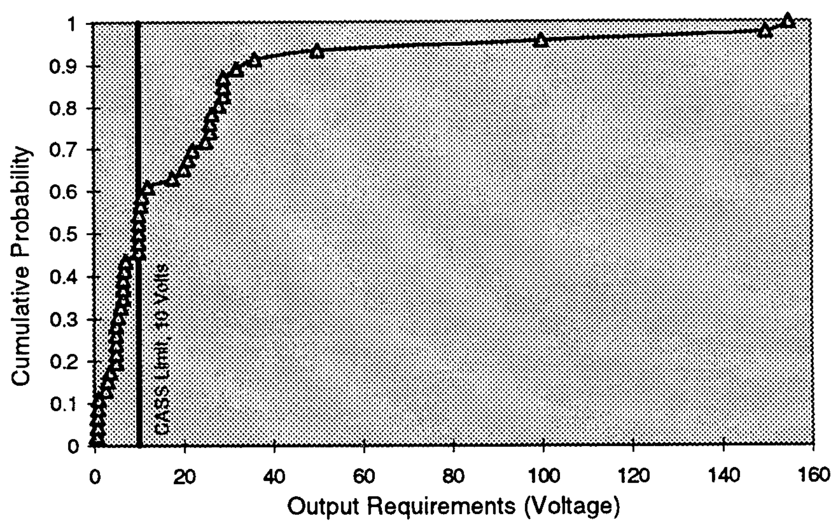


Figure 1-6. Waveform Generation Output

Table 1-31. Pulse Amplifiers

Instrument[a]	Gain (dB)	Power (Out)	Voltage[b]	Frequency	Price
162LPS	55	200 Watts	100 Volts	10- 220 MHz	$5,995
LP400HF	55	400 Watts	141 Volts	5-200 MHz	$13,750
LP300H	53	300 Watts	122.5 Volts	.3- 100 MHz	$9,550

[a] These Kalmus instruments are shown for illustration only.

[b] Across a 50-ohm load.

The pulse amplifier is only a partial solution. Of the three options shown in Table 1-31, consider the 300-watt model as an example. It is much less costly than the 400-watt model, and its 122.5 volt capability enables it to meet all the voltage requirements for pulse generation shown in Table 1-29, and all but two of the voltage requirements for waveform generation shown in Table 1-30. However, the blank entries in the Amplifier Coverage column of these tables show that the 300-watt amplifier fails to meet many of the timing requirements: the repetition periods for pulse generation in Table 1-29 and the frequency requirements for waveform generation in Table 1-30. (The Y's indicate that the 300-watt option meets the timing requirements.) The 300-watt amplifier meets only 10 out of 23 requirements for pulse generation, and only 12 out of the 29 requirements for waveform generation.

Although the new pulse amplifiers would meet most of the requirements for output voltage, they would fail to meet many of the repetition and frequency requirements. External accessories, moreover, create complex test setups, and lack the ability to conduct tests requiring simultaneous pulse and waveform amplification. A more detailed search might find a more-capable, lower-cost pulse amplifier that would make this option more attractive. The pulse amplifier, a COTS instrument, would cost $9,550 per unit. The figures in Table 1-29 and Table 1-30 show the additional UUT population that could be tested if the LP300H amplifier were added: 1,445 UUTs for testing pulse generation and 1,667 UUTs for testing waveform generation. These totals are the sums of the figures in the "relevant population" columns for which there is a "Y" in the "Amplifier Coverage" column.

The second option, modifying the current pulse and waveform instruments, offers a better solution than adding an accessory pulse amplifier. It would give CASS the ability to meet approximately 90 percent of the requirements listed in Tables 1-29 and 1-30. It would also offer the capability for simultaneous pulse and waveform tests, a broader range of repetition rates and frequency coverage, and less-complex test setups. The cost of this option has not been estimated.

Recommendation: For the near term, permit TPS developers to add voltage amplifiers to Interface Devices for UUTs requiring over 10 volts. For the long term, explore the feasibility of increasing the capability for pulse and waveform generation to 30 volts.

2. Digital Multimeter Current Measurement

CASS measures current using the Digital Multimeter. The upper limit of the meter itself is 2 amps AC or DC, but the DC limit can be increased to 20 amps by using the existing programmable load to step-down the current to the meter's capability. With this option, CASS has the capability shown in Table 1-32.

Table 1-32. Measurement Requirements for DC and AC Current

Function	Maximum UUI Requirements	Maximum CASS Capability	Requirements Met (%)	Number of Applications	Coverage (%)
DC Current	125 amps	20 amps	67	11	83.6
AC Current	4.74 amps	2 amps	6	5	16.7

Although Table 1-32 shows that CASS fails to meet our 85 percent criterion for measuring DC and AC currents, there is no compelling reason to make a costly upgrade. The 83.6 percent coverage is just short of the 85 percent criterion, and putting shunt resistors in IDs could meet the remaining requirements.

CASS capability for measuring AC current is limited—a coverage of only 16.7 percent. This measurement, however, is required in only 6.1 percent of all tests (Table 1-4). CASS capability can be increased, moreover, by using transformers to step-down currents to levels that can be measured by the CASS AC current meter. These transformers can be made available through TPS IDs.

Recommendation: Permit TPS developers to insert current transformers into TPS Interface Devices for those systems with AC currents over 2 amps.

D. DIGITAL FUNCTIONS

The existing CASS digital test unit (DTU) generates signals and measures the return outputs to test digital UUTs. Table 1-33 lists CASS capability in the relevant areas.

Tables 1-3 and Figures 1-7 and 1-8 show that CASS meets 70.4 and 63.9 percent of the voltage test requirements for digital stimulus and digital measurement, respectively. Tables 1-34 and 1-35 list the requirements that are not met. Newly produced CASS stations will contain the new Teradyne DTU, which will have an option to test the old 28-volt digital systems that are nearing retirement. The unit cost of the 28-volt option is $2,500.

Table 1-33. Current CASS Capability for Digital Testing

Function	Maximum Voltage	Maximum Current	Data Rate	Number of Pins
Stimulus	15 Volts	.05 amps	40 MHz	168
			20 MHz	336
Measurement	13.5 Volts	.00012 amps	40 MHz	168
			20 MHz	336

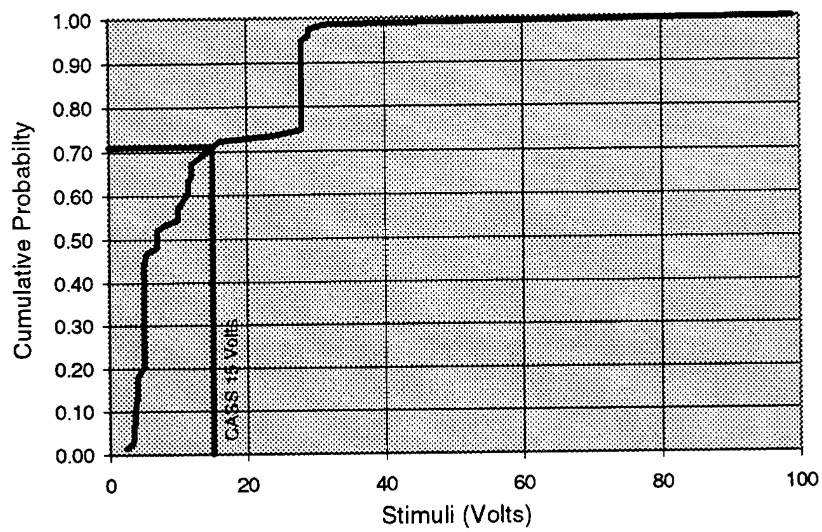


Figure 1-7. Ability of CASS To Meet Voltage Requirements for Digital Stimulus

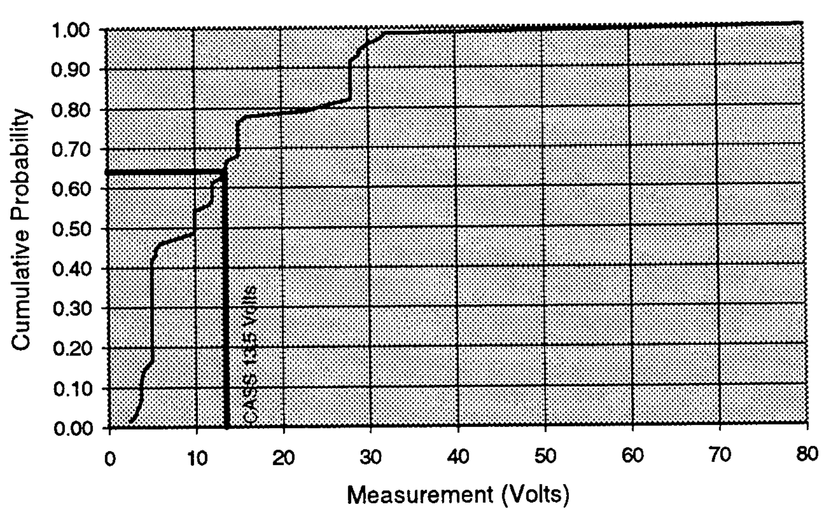


Figure 1-8. Ability of CASS To Meet Voltage Requirements for Digital Measurement

Tables 1-34. Requirements for Digital Stimuli Not Currently Met

System	Volts	Population	Lifetime	CIP	CASS Candidate	Relevant Population
AN/MRC-142	16	500	Y		Y	500
APN-151	24		Y			
AV-8B, CIP	28	255	Y	Y	Y	255
KC-130T, CIP	28	22	Y	Y	Y	22
A-6 IR Rec	28	150				
AV-8B OFLD EETS/HTS, WRA, CIP	28	255	Y	Y	Y	255
AV-8B,OFLD, NonCIP, WRA	28	255	Y	Y	Y	255
F-14D,APG-71	28	56	Y	Y	Y	56
F-14D, GASD	28	56	Y			
F-14D, OFLD, VAST	28	56	Y			
F-14D, OFLD, VAST, CIP	28	56	Y	Y	Y	56
F-14D, WRAs, CIP	28	56	Y	Y	Y	56
S-3, AAM-60, SRA, CIP	28	115	Y	Y	Y	115
ALR-67, WRA	28	701	Y		Y	701
ALR-67, SRA	28	701	Y		Y	701
High Power ATE, WRA, CIP	28			Y	Y	
Avionics, RF& Audio Amplifiers	28					
Avionics Power Supply	28					
AWG-9, SRA	28	393				
F/A-18 C/D, CIP	29	534	Y	Y	Y	534
ALQ-165, CIP	29	311	Y	Y	Y	311
F/A-18 E/F, CIP	31.5	163	Y	Y	Y	163
MV-22, CIP	99	552	Y	Y	Y	552

Because the new DTU will not be retrofitted the CASS stations that are deployed will lack a 28-volt capability. The Navy can retain the capability for testing 28 volts at these installations by keeping the single-system testers that were designed for these systems, at least until the older systems retire or new CASS stations are delivered.

Another way to achieve the higher voltage and current levels required by the older systems is to use comparatively simple (and inexpensive) logic conversion circuitry. For example, a gate-controlled rectifier circuit (basically, amplifiers) could be designed to boost the 13.5 voltage stimulus output of CASS to the 28 volts required by the older systems. Whether this circuitry could achieve the required data rates at the 28-volt level has not been determined. With regard to measurement, resistor attenuator pads designed to match the impedance of the signal line could be used to reduce the 28-volt outputs of the digital systems to the 13.5 volts currently measured by CASS. A resistor pad composed of a 45- and a 50-ohm resistor could allow CASS to test the systems that operate at 28 volts and 0.3 amps.

Recommendations: Acquire the 28-volt DTU option for new-production CASS stations. For UUTs that have voltage levels that exceed the older CASS DTU capability, and that may go to sites already fielded with CASS stations, permit TPS developers to insert logic-level conversion circuitry into the Interface Devices.

Table 1-35. Requirements for Digital Measurement Not Currently Met

System	Volts	Population	Lifetime	CIP	CASS Candidate	Relevant Population
F-14D, IRST, CIP,	13.6	56	Y	Y	Y	56
APM-466, RSTS, WRA, CIP	13.7		Y	Y	Y	
AV-8B OFLD EETS/HTS, SRA, CIP	15	255	Y	Y	Y	255
AH-1W, CIP	15	161	Y	Y	Y	161
CH-53E, CIP	15	206	Y	Y	Y	206
EA-6B, CIP,	15	152	Y	Y	Y	152
UH-1N, CIP,	15	148	Y	Y	Y	148
ARC-210, CIP	15		Y	Y	Y	
MV-22, CIP	15	552	Y	Y	Y	552
ALR-67, WRA	16	701	Y		Y	701
Avionics, RF& Audio Amplifiers	23					
ALR-67, SRA	25	701	Y		Y	701
AV-8B, CIP	28	255	Y	Y	Y	255
AV-8B OFLD EETS/HTS, WRA, CIP	28	255	Y	Y	Y	255
AV-8B,OFLD, NonCIP, WRA	28	255	Y		Y	255
F-14D,APG-71	28	56	Y	Y	Y	56
F-14D, WRAs, CIP	28	56	Y	Y	Y	56
APS-137, WRA, CIP	28	16	Y	Y	Y	16
AWG-9, SRA	28	393				
APM-466, RSTS L3, WRA, CIP	28		Y	Y	Y	
F/A-18 C/D, CIP	29	534	Y	Y	Y	534
ALQ-165, CIP	29	311	Y	Y	Y	311
MK-117	30	9	Y			
F/A-18 E/F,CIP	31.5	163	Y	Y	Y	163
KC-130T, CIP	32	22	Y	Y	Y	22
F-14D, OFLD, VAST	80	56	Y			

IV. SUMMARY OF PART 1

Although the present CASS system was developed as a tester for Navy avionics, our analysis indicates that it also possesses substantial capability to test electronic systems on Navy ships as well as aircraft for which it was originally designed, on Marine Corps aircraft and ground units, and on Air Force aircraft. The analysis did, however, uncover some shortfalls, and we identified some upgrades to reduce or eliminate them. The remainder of this section summarizes these upgrades, along with estimates of their life-cycle costs. We estimated the costs using the model developed in Reference 1 and summarized in Appendix B of the present report.

We present the recommendations in Table 1-36 and Table 1-37 based on immediacy. Table 1-36 lists those upgrades, along with their 10-year costs, for which a shortfall exists at present, and that are therefore recommended for attention in the short run. We chose these improvements with the following criteria in mind:

- The upgrade solves a current shortfall.
- The shortfall affects a relatively large population of systems.
- The upgrade is relatively low in cost.

Table I-37 lists those improvements, along with their 10-year costs, for which a test requirement is anticipated to emerge in the longer term. These upgrades generally meet the following criteria:

- A requirement does not exist at present, but might appear in the future.
- Technology is not fully available, at present, to meet the requirement.
- The upgrade is more costly.

Table 1-36. Near-Term CASS Upgrade Candidates

Test Characteristics	Recommendations	Develop-ment[a] ($)	Unit Procure-ment ($)	10-Year[b] ($M)
		Costs		
RF Stimulus, Minimum Output	Add programmable attenuator		$2,500	$0.57
RF Synthesizer Replacement	Replace 20 and 40 GHz synthesizer with MMS technology units[c]		$3,000	$0.97
Power Measurement, Maximum Power	1. Add a sensor for +44 dBm		$1,820	$0.31
	2. Add an attenuator		$480	$0.11
RF Resistive Load	1. Add DC to 2.5 GHz 1,000 watt loads		$895	$0.20
	2. Develop RF load accessory	$760,000	$15,200	$3.40
RF Noise	Activate RF noise measurement software		$5,000	$1.13
Total Cost				$6.69

[a] Including cost of integration.

[b] Cost, in millions of FY 1995 dollars, for development, integration, procurement of 100 units, and 10 years of operations and maintenance.

[c] This upgrade offers the benefits of greater ruggedness and smaller size, thus creating space for more instruments in the CASS station. In considering this upgrade for new stations, planners would have to consider the cost of the new synthesizers relative to the cost the present units, which is approximately $3,000.

Table 1-37. Future CASS Upgrade Possibilities

Function	Option	Develop-ment[a] ($)	Unit Procure-ment ($)	10-Year[b] ($M)
		Costs		
RF Stimulus Frequency	1. Add 40 to 60 GHz		$11,750	$2.03
	2. Add 40 to 75 GHz		$28,050	$4.84
	3. Add 40 to 110 GHz		$44,350	$7.66
	4. Field units acquire capability as needed			
RF Stimulus Maximum Output	1. Add broadband amplifier			
	2. Add Synthesizer with greater output			
	3. Add capability to Interface Devices		$2,095	$0.47
RF Power Measurement Frequency	1. Extend range of Power Meter to 50 GHz			
	a. To 50 GHz		$2,595	$0.45
	b. From 75 to 110 GHz		$6,200	$1.07
	2. Extend range of Spectrum Analyzer			
	a. From 26.5 to 40 GHz		$17,350	$3.00
	b. From 18 to 40 GHz		$4,795	$0.83
DC Resistive Load	1. Add supplemental load bank	$540,000	$11,000	$2.49
	2. Add to Interface Devices as required			
Phase Noise	1. Add Absolute Phase Noise with Local Oscillator (Uses two Los)		$85,000	$19.24
	2. Add Absolute Plus Phase Noise with Local Oscillator		$96,500	$21.84
	3. Add Absolute Phase Noise without Local Oscillator		$65,000	$14.71
	4. Add Absolute Plus Additive Phase Noise without Local Oscillator		$76,500	$17.31
RF Interface Matrix Switch	1. Add two multiport switches	$470,000	$9,400	$1.62
	2. Add a 10x10 Matrix Switch	$150,000	$35,500	$6.13
Pulse and Waveform Generators	1. Add a Pulse Amplifier			
	2. Modify Pulse and Waveform Generators to increase output		$9,550	$1.65
Digital Stimulus and Measurement	1. Use CASS but add logic level conversion to Interface Devices			
	2. Acquire the 28-volt option in the new DTU			
Total ECPs		$470,000	$102,340	$21.88M

[a] Including cost of integration.

[b] Cost in millions of FY 1995 dollars, for development, integration, procurement of 100 units, and 10 years of operation and maintenance.

PART 2
CASS SOFTWARE

I. INTRODUCTION

A. TASKS

This part of the report discusses our research on the four software tasks mentioned in the introduction to the study.

1. Task 1. Cross and Upward Compatibility

Tasks 1 and 2 concern the issue of compatibility—the ability of a TPS that was developed on one type of CASS station (one set of instruments, and other hardware) to run on a different type of station (a similar, or different set of instruments). Cross compatibility concerns the situation when the two sets of hardware are *identical*—when a TPS that has been designed for a Hybrid station is run on another Hybrid station. Upward compatibility, on the other hand, refers to the case where the TPS is run on a station that contains a *superset* of instruments (more instruments that those on the station on which the TPS was developed). An example is running a Hybrid TPS on an RF station. (RF stations are Hybrids plus additional instruments.) Upward compatibility will become an issue when downsize CASS stations are developed, or when maintainers move TPS between full-size stations, such as from a Hybrid to an RF station.

2. Task 2. Downward Compatibility

Downward compatibility, which is another issue that will arise when downsized CASS stations are developed, is the ability to run a TPS on a CASS station that contains a *subset* of the hardware in the station on which the TPS was developed. Will TPSs that are constructed using current design standards be able to perform more limited tests on the downsize stations, which will not contain a full set of needed resources? What changes to current design procedures will be needed?

In one typical scenario, a failed electronics item on a carrier escort (or amphibious ship) would be subjected to a go/no-go, or functional test on board the escort to verify that the item is not working. The item would then be lifted or high-lined (transferred at sea) to the carrier for a more extensive parametric test designed to diagnose the problem for purposes of repair (fault-isolate the problem to the particular circuit board or chip that

must be replaced). Here, the question is, what types of TPSs would be most economical: two single-configuration TPSs, one for full stations and one for downsize stations, or a single, multiple-configuration TPS that can perform on all CASS configurations?

3. Task 3. General Improvements to CASS Station and TPS Software

Apart from these issues of compatibility across new CASS configurations, there is the question of what actions can be taken to reduce the cost and increase the capability of today's TPS and station software. We will consider some changes to TPS programming practices regarding hardware-dependent functions, Functional Extension Programs, software tools in TPS development, and the station software.

4. Task 4. Long-Term Roadmap

In the coming years, CASS software must comply with recent OSD policy that requires increased use of commercial standards. In addition, CASS may be able to benefit from new software standards and languages being studied and developed by the IEEE (Institute of Electrical and Electronic Engineers, Inc.). We will propose a time-phased roadmap for implementing these changes.

B. DEFINITIONS

Software is a technical area that involves a host of specialized terms. The terms used most often in this part of the study are defined below. Other terms will be defined as they are used. (An "Abbreviations" section at the end of the report contains a larger list of terms used in this study.)

ATE	Automatic Test Equipment: the station software and computer, stimulus and measurement instruments, power supplies, and interfaces.
ATLAS	A Test Language for All Systems: a standard language maintained by the IEEE Standards Coordinating Committee 20. The designator is IEEE-Std-716. Recent releases have taken place in 1985, 1989, and 1995. The next scheduled release is in 2000.
ATS	Automatic Test System: consists of an ATE, one or more TPSs, Interface Devices (IDs), and associated documentation.
CASS software	The station software, TPS software, and the development tools that comprise the software environment in which CASS TPSs are written.

Development environment	The set of software tools and computers (including simulators) used to develop TPSs. In many cases, the ATS itself is used as the development environment.
DGAR	Designated Government Acceptance Representative: agents of the TPS developing agencies who oversee the work of government personnel and contractors in developing TPSs. They ensure that TPS developers follow the TPS contract, and rule on requests for exception.
FEP	Functional Extension Program: a collection of code written in a language other than ATLAS, the standard language used for writing test software. FEPs are written to obtain capabilities that are not available in ATLAS, or that are more easily programmed in another language.
IEEE	Institute of Electrical and Electronic Engineers: a non-profit service organization that produces and maintains commercial standards.
Red Team Package	A Navy-wide package of procurement and contract documents and other materials that are developed for TPS procurement. Each TPS procurement tailors this package for its use.
TPS	Test Program Set: the hardware and software that enable an ATE to test a particular UUT. The TPS consists of the hardware ID, the cables that connect the ATE to the UUT, the software to run the test procedures, and any required documentation.
UUT	Unit Under Test: either a Weapons Reparable Assembly (WRA) or System Reparable Assembly (SRA).

C. GENERAL FINDINGS

The current CASS software system is capable of fulfilling its current mission as a tester for Naval Aviation. All current TPSs are being designed to standards that provide compatibility across the full CASS configurations (Hybrid, RF, CNI, and EO). Regarding the problem of upward compatibility, TPSs written for future downsize CASS stations are capable of being designed for compatibility with full CASS stations.

Current TPS design standards will require changes to achieve downward compatibility between full and downsize CASS stations. The more economical option is to

develop new multiple-configuration TPSs, rather than single-configuration TPSs. For a case involving 270 UUTs, the multiple-configuration option saves $21 million plus $9 million annually. A one-time investment of approximately $125,000 would be required in CASS station software to use multiple-configuration TPSs. In addition, there would have to be some changes in the way TPSs are developed.

As a general matter, any modifications should be evolutionary, backward compatible, and require no major changes to existing TPSs. Otherwise, the necessary retrofits would require costly changes involving hundreds of software programs.

Some general improvements to CASS software are in order. The Program Office should take steps to discourage (but not deny where absolutely needed) the use of hardware-dependent programming and FEPs. Hardware-dependent instructions lead to problems of incompatibility when the station computer is upgraded, and FEPs can create operational and maintenance problems due to their lack of standardization. The practices can be discouraged by providing some improvements to the ATLAS compiler, by giving appropriate guidance to DGARs, and by writing sections in the new style guide that is under development. The Program Office should also take steps to encourage greater use of software tools in developing TPSs. Existing tool sets should be used more often, and efforts should be sponsored to develop new tools. Some of the DO DIGITAL functions (described later) should be incorporated into the station ATLAS language in order to make digital testing more uniform and compatible with other ATLAS programming, and to reduce the use of FEPs.

Finally, we constructed a roadmap of long-term software changes to bring CASS into compliance with the new OSD policy regarding the use of commercial standards, and with the new languages and standards under study and development by the IEEE. These software changes, once tested for their application to CASS, could be released to the Fleet at two-year intervals.

II. ANALYSIS

A. TASK 1: CROSS AND UPWARD COMPATIBILITY

Currently written CASS TPSs are specifically designed to be compatible across the current CASS configurations (Hybrid, RF, CNI, EO) when the list of required assets derived for the TPS are present in the work station. Properly written software will transport and run on other CASS stations. This does not mean that the software will behave the same on all stations and with all UUTs. Several factors may affect functioning. These include configuration control and the setting of tolerances. FEPs can also alter the picture, because they may be used to circumvent configuration control. These topics will be discussed in turn, before turning to the specific issues of compatibility.

1. Configuration Control

Maintaining tight configuration control of CASS stations is crucial when upgrades are made to the CASS hardware. A retrofit program may be needed to ensure cross and upward compatibility during upgrades of components such as the central processor (CPU) or the Digital Test Unit (DTU) that affect the operation of the entire station. For example, consider two analog measurements, one that requires a 300 msec delay to allow for settling of the system, and another that requires a 10 msec measurement to be made within 50 msec of settling. The code to accomplish these measurements may be different on stations with different CPUs (all else being equal). To a large extent, proper (hardware-independent) programming practice can decrease this burden.

2. Tolerances

The inability to hold strict tolerances is another practical problem in ensuring that upgrades will run in a consistent fashion. The situation is complicated because there are three tolerances that enter into the testing situation: those pertaining to the UUT, the TPS, and the CASS station. Figure 2-1 presents an illustration. The solid curve shows the results of errors in producing the UUT. The production process is designed to produce UUTs at the design target of 20 volts, but random variations in the production process

lead to a normal distribution of UUT voltages centered on the design target. (The standard deviation is shown larger than normal for purposes of illustration.)

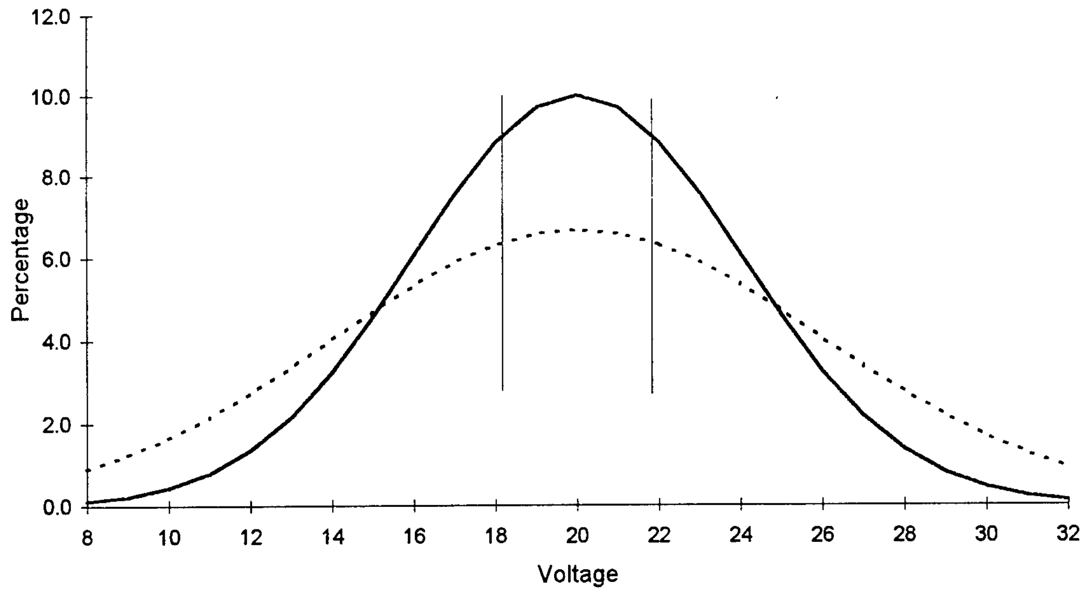


Figure 2-1. Testing Tolerances

Assume further that TPS designers determine that the UUT will function properly at any voltage from 18 to 22 volts, and use this as the acceptance region for the UUT (shown by vertical lines). So far, we are assuming that all CASS stations and TPSs are built to specifications with zero tolerances. And in this case, there will be no testing errors, either of Type I (rejecting good UUTs, those within the 18-22 volt range), or of Type II (accepting bad UUTs, those outside the 18-22 volt range).

In fact, however, CASS stations and TPSs are not built with zero tolerances. We will assume, for illustration, that test results are biased over the range from -1 to +1 volt, depending on the TPS and CASS station. That is, when the CASS instruments measure 18 volts, the actual voltage may be anywhere from 17 to 19 volts. This widens the distribution of UUT voltages that are read by the TPS and station (dotted curve). There are now both Type I and Type II errors. TPS developers can choose to minimize the Type II errors (accepting fewer bad UUTs) by narrowing the acceptance region (from 19 to 21 volts, for example), but only at the cost of more Type I errors (rejecting more good UUTs). Alternatively, they can widen the acceptance region (from 17 to 23 volts, for example), which will have the opposite effect.

Both types of error can be reduced by better quality control. Minimizing life-cycle cost would ideally require designing the UUTs, the CASS stations, and the TPSs in a single, coordinated program, but this is hardly a realizable goal. The issue of COTS (Commercial Off-The-Shelf) instruments enters into the picture, in that although these instruments are generally less expensive, the tolerances of these instruments are not determined by the station developers. Custom instruments might involve tighter tolerances, but analysts would have to consider each case to decide if the savings in testing is worth the added cost of the instruments.

With regard to the question of whether the TPS developer should push for narrower or tighter acceptance regions, the answer depends on the individual situation: what the UUT distribution looks like, how large the TPS and station measurement biases are, and what the dollar and operational costs are of both types of error. There are currently no satisfactory guidelines for making these tradeoffs. A tool that can simulate the UUT/CASS combination would be required to provide the required quantitative data. Meanwhile, one can expect some rejection of good UUTs and acceptance of some bad UUTs for properly developed test programs.

3. Compatibility

The software in the CASS station has been designed with upward and cross-compatibility. Problems still exist, however, and they can be addressed (although maybe not completely solved) by configuration control and providing proper tools. Further, the TPS developer should be made aware of to what criteria his TPS is expected to perform: minimum probability of rejecting good UUTs, minimum probability of accepting bad UUTs, or some compromise.

B. TASK 2: DOWNWARD COMPATIBILITY

We would like for TPSs developed for full CASS stations to be able to use the subset of instruments on downsize CASS stations as well. The question is whether these TPSs could tolerate the absence of some instruments without locking up. Given that currently designed TPSs do *not* have this capability, as we will show, there are various interrelated options:

- give all users "override" privileges;
- modify the software of the downsize stations accordingly;

- develop single-application TPSs, one TPS for each configuration of CASS that must have the capability of testing the UUT; and
- construct multiple-application TPSs that can run on any CASS configuration.[1] Some modifications of station software will be required in either of the last two options.

1. Can Current TPSs Run on Downsize CASS Stations?

The current software on CASS stations prevents the running of TPSs in cases of mismatch—when the assets that the TPS calls for are not all present in the station. This task is performed by the Test Executive. It compares the list of station assets with the list of assets required by the TPS, and prevents the TPS from running when there is a mismatch, unless the operator invokes an "override." Some CASS users, particularly those who are involved in developmental work, are granted override privileges, which permit the TPS to be run with a mismatch. Since the override privilege is only given to a few users, however, the answer to the question of whether current TPSs have downward compatibility must be no.

2. Granting More Users the Override Privilege

Expanding the class of users with override privileges would be simple, but the benefits are unclear. We have not been able to get a definitive answer from CASS engineers as to what the outcome would be if the override is invoked and the TPS asks for assets that do not exist. The responses include (1) the system will hang up, (2) erroneous test outcomes will occur, and (3) the operation will be unsafe. We have rejected this option because its results are unpredictable, so far. Actual tests could certainly help to reduce the uncertainty, but the response would probably depend on the TPS, the station resources involved, and other variables. There is also the risk that some tests may damage the station hardware.

3. Adding a "Watchdog" to the Station Software

The problem of how to use current TPSs on downsize stations could be solved without expanding the override privilege and incurring the resulting unpredictability by making a simple modification to the station software: incorporating a "watchdog" within the Test Executive. The watchdog would query the station at the start of a test, determine

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[1] In using the term "configuration" in this section, our focus is on full vs. downsize CASS, not Hybrid vs. the other full CASS versions (RF, CNI, and EO).

which instruments are absent or not working, and prevent the TPS from trying to access these instruments.

The watchdog alternative would require mainly a single software development project. The software could be distributed by the Naval Air Warfare Center, Aircraft Division, at Lakehurst, NJ, in one of their periodic software releases to CASS users. The Work Breakdown Structure (WBS) analysis in Table 2-1 indicates that a rather sophisticated watchdog, one that includes three levels of checking, could be developed for under $125,000. The figures were derived by Test Automation, Inc., and reviewed by Martin-Marietta engineers. (The $125,000 does not include the relatively negligible costs of distributing the computer media.) The watchdog would have no effect on TPSs that are existing or in the process of construction, but such TPSs may have to be re-compiled in order to run with the new software release.

Table 2-1. Cost of a Station Watchdog

	Hours				
	Program Manager	Engineering Manager	Software Engineer	Documentation	Cost[a]
Design and Development					
1.1 System design assessment		16		80	$7,440
1.2 Watchdog level 1 code		16	160	80	7,440
1.3 Watchdog level 2 code		48	480	160	21,120
1.4 Watchdog level 3 code		48	480	160	21,120
1.5 Test		24	240	240	12,960
1.6 Integration		32	320	320	17,280
Documentation					
2.1 Programmer's manual		16	120	40	5,440
2.2 Software specification updates		24	240	240	12,960
Management					
3.1 Program management	80				3,600
3.2 Reviews	48	48	48		5,760
Release					
4.1 Software update incorporation	24	16	80	80	5,720
Total					$120,840

[a] The hourly rates are $45, $40, $35, and $15 for the PM, EM, SE, and Documentation, respectively. These rates include 100 percent for overhead, 15 percent for G&A, and 15 percent for fee.

4. Comparing Single-Application and Multiple-Application TPSs

The remaining two options solve the downward compatibility problem through TPSs—designing single TPSs for each configuration, or requiring TPS developers to

design multiple-application TPSs that could perform whatever tests are possible with the assets (instruments, power supplies, etc.) that are present and working in whatever CASS configuration is being used.

The least-cost solution for those TPSs which are already under contract—approximately 1,200 out of the 2,400 TPSs the Navy plans for offload to CASS—is probably to develop a new single-application TPS for downsize stations that might be developed. However, most of the TPSs now existing or under contract are airwing avionics and thus not candidates to run on both the full-size (carrier) and downsize CASS. Constructing multiple-application TPSs would simplify testing in that the Navy would have a single TPS for each UUT. The advantages do not appear to justify the cost, however, since we already have TPSs for the full-size stations, either in the Fleet or under development. The remainder of this analysis will therefore consider the choice between single- and multiple-application TPSs for the 50 percent of the TPSs that are yet to be placed under contract.

The multiple-application solution would require TPS developers and station software engineers to design TPSs with the following capabilities:

- Identify those assets that would normally be present but that are absent in downsize CASS, and also those assets that are present but not working.
- Contain programming to work around the missing or failed assets. The TPS could either eliminate those tests that would involve the missing or failed assets, or allow all tests to proceed but simply move on if a missing or failed asset is encountered.

With either option, some changes would have to be made to the CASS user control systems or compiler (in particular, the IMOM and SMATS, the Intermediate Maintenance Operations Management System and the Self Maintenance and Test System). Even with these changes, however, some modifications would be required to protect CASS from programmer errors. (The watchdog described above can provide that function.) The solution does, however, relieve the burden from the CASS operator. (No override should be necessary.)

We compared these single-application and multiple-application alternatives by estimating the respective development costs of producing TPSs for 270 UUTs that would be used on both aircraft carriers and escorts. (The two alternatives are not relevant for testing UUTs that are used on either carriers or escorts, but not both.) Note that the number of carriers and escorts on which the UUTs are found does not enter into the cost

comparison. These numbers affect only the procurement and distribution costs of the alternatives, which are negligible compared with the development costs.

The selection of 270 UUTs was made by assuming that if downsize CASS configurations are, indeed, produced, then the number of TPSs that could be produced by either alternative would be equal to 10 percent of the number of TPSs produced from now until FY 2000, according to the TPS procurement schedule developed by PMA-260. This calculation yielded 270 TPSs. Table 2-2 shows a somewhat idealized production schedule for the 270 TPSs, assuming 2 years for development and 1 year for production.

The two alternatives are therefore (1) developing 270 full TPSs for UUTs on carriers and 270 different, but similar, TPSs for the same UUTs on escorts, and (2) developing 270 multiple-application TPSs for UUTs on both carriers and escorts. The development costs for these options were estimated using the Jacksonville TPS ROM (Rough Order-of-Magnitude) Development Cost Model. This model calculates total development cost using variables describing the number of UUTs requiring TPSs, the numbers of TPSs to be developed per year, their distribution between WRAs and SRAs, and the complexity of the TPSs. Table 2-3 shows the inputs selected for the final comparison. They are discussed below.

Table 2-2. Number of CASS TPSs Run on Escorts and Carriers

	Fiscal Year					
	1998	1999	2000	2001	2002	2003
In development, 1st year	90	90	90	—	—	—
In development, 2nd year	—	90	90	90	—	—
In production	—	—	90	90	90	—
In field use	—	—	—	90	90	90
In field use, cumulative	—	—	—	90	180	270

Table 2-3. Input for Estimating TPS Development Cost

Program Assumptions	
Total Number of UUTs	270
Number of TPSs	
Single TPS alternative	540
Multiple-application alternative	270
Duration	3 years (1998-2000)
Number of lots	6
Number of TPSs per lot	45
Composition of each lot	
WRAs	5
SRAs	40
Unit Development Cost per UUT, relative to average	
Single TPS alternative	
TPS for full CASS	100 %
TPS for downsize CASS	50 %
Total	150 %
Multiple-application alternative	125 %
Annual Recurring Cost per TPS, relative to average	100 %

The TPSs are assumed purchased in lots, a common practice to save money. Each of the yearly 90 TPSs are produced in 2 lots, each lot consisting of 5 WRAs and 40 SRAs.

The Jacksonville model estimates the cost of currently designed TPSs using cost factors that are based on historical data. (TPS development cost depends significantly on the complexity of the TPS, and we assumed an average complexity factor for the current TPS.) We therefore had to input information to the model that related these current TPS cost factors to those of the new-design TPSs we are analyzing—the single-application TPSs for downsize CASS stations and the multiple-application TPSs. The cost factors for the latter TPSs clearly involve some uncertainty. Early runs of the model using what seemed to be reasonable estimates for these factors indicated that the multiple-application TPS solution was far more economical than the single-application TPS.

However, because the multiple-application TPSs represent more of a break with current practice than do the single-application TPSs, the costs of the multiple-application TPS are more likely to be underestimated. To avoid a biased solution, we therefore chose final inputs (those in Table 2-3) that were weighted against the multiple-application solution. Along these lines, we assumed that having developed a current-design, single-application TPS for a full CASS, developing a single-application TPS for a downsize

CASS would cost only 50 percent more. We assumed that developing a multiple-application TPS, however, would cost 125 percent of the average development cost of a current TPS.

The annual recurring cost for a single TPS, either full or downsize, was set equal to the average annual recurring cost of a current TPS. The recurring cost for a multiple-application TPS was set equal to 150 percent of the current recurring cost (but is less costly overall because fewer units are required).

Table 2-4 shows the final results, obtained by inserting the above factors into the Jacksonville ROM TPS Cost Model. The multiple-application TPS solution is much less expensive than constructing separate TPSs for each configuration. This option also has added advantages resulting from the lower inventory of TPSs: lower logistics costs, simpler configuration control, and simpler bookkeeping. The cost advantage of the multiple-application solution is even large enough to justify implementing this option on its own merits, apart from its advantage in achieving downward compatibility. The single-application option, however, does have an advantage in that it can be implemented immediately, whereas the multiple-application solution requires some development. To verify and refine the above analysis, we suggest that the CASS TPS Working Group (TWG) evaluate the costs and benefits of the two solutions in detail.

Table 2-4. Comparison of Single-Application and Multiple-Application Alternatives

	Non-recurring	Yearly recurring
Single-Application Alternative		
Cost per UUT		
TPS for full CASS	\$311,111[a]	\$48,148
TPS for downsize CASS	\$155,555[b]	\$48,148
Total	\$466,666	\$96,296
Number of UUTs	270	270
Total cost of program	\$126 million	\$26 million/year
Multiple-Application Alternative		
Cost per UUT		
TPS for multiple-application TPS	\$388,875[c]	62,963
Number of UUTs	270	270
Total cost of program	\$105 million	\$17 million/year
Multiple-Application Savings	\$21 million	\$9 million/year

[a] Average development cost of TPSs of average complexity.

[b] 50% of average development cost.

[c] 125% of average development cost.

C. TASK 3: GENERAL IMPROVEMENTS TO CASS STATION AND TPS SOFTWARE

This task involves some general improvements (i.e., not involving the particular issue of downsize CASS compatibility) that could be made to TPS and station software. The following are the areas of improvement that relate to TPS development:

- Minimizing FEPs.
- Incorporating ATLAS-compatible digital testing (DO DIGITAL).
- Expanding the use of software development tools.
- Developing a style guide.
- Minimizing hardware-dependent programming.
- Expanding the Red Team Package (TPS procurement package).
- Strengthening the role of the DGAR.

1. Minimizing FEPs

Configuration control is an important requirement if TPSs are to perform in a repeatable fashion across different CASS stations and UUTs. Functional Extension Programs are one way in which configuration control is lost. FEPs are special-purpose blocks of code that are written in languages other than ATLAS and that are called from within the ATLAS code.

FEPs are of two types, which differ in the degree of loss of configuration control. The first type is that which has been incorporated into the standard ATLAS library. These FEPs include those that are used to control some limited functions of the DTU and those that are referred to as ATLAS Standard Data Processing. Because these FEPs have been developed in a controlled setting, they are generally efficient and easy to maintain (debug and improve).

The second type of FEP is that which is created by TPS programmers during the development of individual TPSs. These FEPs may be used to access characteristics of the station's instruments (amplitudes, frequencies, etc.) that lie beyond the characteristics imposed by the ATLAS code. It is clear that TPS developers use FEPs because they reduce the cost and time of development. However, there are indirect costs and benefits to these kinds of FEPs. On the cost side, they represent a substantial loss of configuration control. Each TPS developer writes his own FEPs using the computer languages of his choice, and for whatever purposes he requires. Because these types of FEPs are unique,

they create problems of software maintenance (debugging and modification). Moreover, they can not be made part of the training program for operational maintainers, who must therefore study them on their own when knowledge of TPS code is required. Finally, because standard software tools cannot be brought to bear in constructing FEPs, they tend to be error prone and costly to produce.

There are other costs that depend on the particular reasons for the disparity between the station's instruments and ATLAS constraints. Some CASS specifications are purposefully set lower than instrument specifications for safety reasons, to avoid reductions in the reliability of the hardware, or to increase instrument life. FEPs should definitely be discouraged in these cases.

Some disparities between specifications and capabilities arise when instruments are replaced with newer models that have higher performance. Although using FEPs in this case would offer definite benefits, the lack of configuration control suggests that a better remedy would be for the Program Office to issue a quick update of the published CASS specifications as soon as an instrument is replaced with one of higher capability. In the interests of configuration control, the Program Office would have to ensure that all CASS stations had the requisite capabilities.

Given that FEPs lead to some loss of configuration control, it would be well to establish a formal review procedure whereby TPS developers must present their case to the DGARs. For the longer run, the Program Office should sponsor a program to construct a standard set of FEPs that have been found to be useful and that do not compromise safety, reliability, or instrument life. The standard FEPs could be included in the CASS/ATLAS library.

2. Incorporating ATLAS-Compatible Digital Testing (DO DIGITAL)

The application of FEPs to digital testing is a special case. All digital testing in CASS is performed using FEPs written in the Teradyne L-200 code to drive the DTU. Although some digital functions must certainly be performed this way, much of the work now being done by the FEPs could instead be handled by simple ATLAS-like statements. A set of standard constructs called DO DIGITAL has already been established. The DO DIGITAL constructs use the 1985/89 IEEE ATLAS language, and include both static and dynamic applications.

The question is, which of the DO DIGITAL ATLAS commands are stable, could be readily implemented, and would provide sufficient capability? The static functions

within the ATLAS DO DIGITAL constructs meet these requirements. Static digital applications require a large amount of file handling, and the DO DIGITAL constructs include array handling that has been developed for the task. The seven basic functions listed in Table 2-5 would handle an estimated 70-80 percent of current digital test requirements.

Table 2-5. Recommended DO DIGITAL Constructs

Construct	Action
Stimulus Only	Applies a series of stimulus patterns to the UUT
Response Only	Retrieves a set of response patterns from the UUT
Response Compare	Retrieves a set of response patterns from the UUT, compares them with expected responses, and records the mismatch data
Stimulus-Response Save	Applies a set of stimulus patterns to the UUT and stores the response patterns
Stimulus-Response Compare	Applies a set of stimulus patterns to the UUT, compares the response to expected responses, and stores the mismatch data
Stimulus-Response Match	Applies a set of stimulus patterns to the UUT, compares the response to expected responses, and branches on either match or mismatch
Response Match	Retrieves responses from the UUT, compares each response to a defined pattern or set of patterns, and executes a stated condition on either match or mismatch

The Program Office should require that these constructs be placed in the compiler of the station computer. The compiler can retrieve and imbed them in the TPS, thus making it more fully ATLAS. When one of these static DO DIGITAL functions is encountered during a test, the computer compiler would retrieve it and imbed it in the code. The constructs would thus be transparent to the TPS developers and software maintainers. In addition to achieving benefits of standardization, placing the constructs in the station compiler would provide a single point of control for the seven functions.

Table 2-6 gives the costs of incorporating the seven functions in the station compiler. The figures, derived using a Work Breakdown Structure and a proprietary program developed by Test Automation, were reviewed by Martin Marietta (now Lockheed Martin) personnel. The $40,000 cost is lower than expected because Martin Marietta has previously worked on these functions for the compiler, even though it has not fully implemented them.

Table 2-6. Cost of Implementing CASS Static Digital Constructs

	Hours				
	Program Manager	Engineering Manager	Software Engineer	Documen-tation	Costs[a]
Design and Development					
1.1 System design assessment		8	80		$3,120
1.2 Language design		4	44		1,560
1.3 Implementation		20	200		7,800
1.4 Test		8	80	80	4,320
1.5 Integration		8	80	80	4,320
Documentation					
2.1 Programmer's manual		16	80	80	4,640
2.2 Software specification updates		16	80	80	4,640
Management					
3.1 Program management	40				3,600
3.2 Review	16	16	16		1,920
Release					
4.1 Software update incorporation	24	16	80	80	5,720
Total					$39,840

[a] The hourly rates for these personnel and documentation are $45, $40, $35, and $15, respectively.

[b] These rates include 100 percent for overhead, 15 percent for G&A, and 15 percent for fee.

Dynamic digital applications are more difficult. They involve timing, and therefore tend to be hardware-dependent. Partly for this reason, they have not been successfully implemented in a number of test environments. These applications should be done with standard FEPs. (The L-200 code is robust and suitable for use here.)

3. Expanding the Use of Software Development Tools

Historical experience shows that developing TPSs is a costly process. The Jacksonville TPS ROM Development Cost Model, which is based on extensive case studies, predicts very long development times, ranging from 6 months up to 2 years for complex TPSs. Software tools can reduce the cost and time of TPS development in three ways. First, they can increase the efficiency of code-writing by speeding up the production and increasing the quality of initial code-writing. Second, they can be used to set tolerances at the most reasonable levels, generate detection and isolation statistics, and develop efficient diagnostic strategies. Third, software tools can shorten the time to test TPSs. One of the principal reasons for long TPS development times is the relative scarcity of CASS stations and UUTs that are available for testing new code. Because these stations and UUTs must be diverted from operational use, they are typically in short supply, and the shortage results in a queue of TPS developers waiting for on-station test periods. By

using simulations to substitute for the use of CASS stations and UUTs, software tools can reduce the cost and time to develop TPSs. Otherwise, TPS developers must make a full hookup between a CASS station, the UUT, and the ID for the purpose of debugging and fine tuning.

Despite their important contribution to TPS development, software tools are not used as often as they should be. TPS developers do not always use the tools that already exist because they may be unaware of their potential benefit, or even of their existence. Further, it is not clear how a developer could justify the costs of these tools, given that TPSs are currently procured through individual, competitive, fixed-price contracts. One possibility would be for the CASS program office to buy or finance the development of tools and provide them to the TPS developers as Government Furnished Equipment.

In addition to encouraging the use of existing tools, we recommend developing new tools in the areas of graphical presentation of test results, simulations of CASS stations, simulations of UUTs, and the setting of tolerances. The benefits of such tools would be greater in situations involving complex TPSs.

Because of the great contribution that software tools can make to TPS generation, we recommend that the Program Office empower DGARs to require developers of complex TPSs to use software tools. Requiring the application of tools such as simulation can resolve issues during Preliminary Design Review (PDR) instead of at the Final Acceptance Test. The remainder of this section describes some of the types of tools that could make a significant contribution to TPS development.

Graphical user tools have proven to lower development cost and increase the quality of software. Integrating the DICON (development icon) developed by GE and Martin Marietta is one possibility. Better presentation graphics, combined with the DICONs, would provide TPS developers with a General Purpose Test Equipment (GPTE) capability.

Automated information tools, such as the Automated Technical Information (ATI) system used on the CASS station, could be modified for use in developing TPSs.

TESIM (Test Simulation) interface to UUT simulation is another analog tool that should be developed. TESIM, currently used to simulate the CASS station, takes a canned input from the UUT. An improved tool that allowed for a UUT simulation input to TESIM would provide a more robust simulation.

Simulation tools for digital testing, such as the LASAR (a fault simulation tool) developed by Teradyne, could be made available. The IDSS (Integrated Diagnostic Support System) tools, especially WSTA (Weapon System Testability Analyzer), can help TPS developers determine fault universes and resolve ambiguities. They can also help the DGAR determine such factors as the degree of ambiguity, the correctness and completeness of the anomaly set, and the sensitivity to tolerances, thus helping him determine the need for redesign. These Navy-owned IDSS tools can be adapted to the TPS development environment. They would provide a direct link between the station and TPSs. Certain technical fixes would be required in the IDSS software.

Fault allocation tables should be provided to TPS developers prior to PDR. The fault allocation table is negotiated between the TPS developer and the acquisition agent. This table would provide the DGAR with an explicit listing of faults to be covered by the TPS. The fault allocation table could therefore be used as the focal point of a new systematic procedure to determine if the TPS meets testability needs, and thus help to eliminate technical debates between the DGAR and the test engineer at the Final Acceptance Test.

The *Diagnostic Modeling Handbook* now under development by the Naval Underwater Warfare Center under the sponsorship of PMA-260 should be completed and distributed as soon as possible, to help in the large CASS re-hosting effort now in progress. (Re-hosting means transforming TPS from another tester to CASS—a new host.) The Navy's IDSS tool sets [WSTA and ADS (Adaptive Diagnostic System] in particular) should be updated to be compatible with this handbook.

4. Developing a Style Guide

The Program Office commissioned the Naval Air Station (NAS) at Keyport to produce a comprehensive style guide that combines the *Style Guide for Development of CASS TPSs* written by the Naval Air Warfare Center Aircraft Division at Lakehurst, NJ, with the templates constructed by the Naval Surface Warfare Center at Crane, IN. The Lakehurst guide is very readable, and the Crane templates, by reducing the amount of duplicative setup activity, can further ease the problems of following the guide.

It would help TPS developers, however, to add some new sections to the style guide. As we mention below, a section should be added to discourage TPS developers from using hardware-dependent programming and FEPs. The guide also needs

modification to accommodate the Secretary of Defense memorandum of June 29, 1994, calling for restricted use of military standards.

5. Minimizing Hardware-Dependent Programming

TPS programmers often use hardware-limited functions of the station computer such as addressing, cycle time, and instruction behavior to control various aspects of a TPS. This may lead to incompatibilities when the CASS computer is upgraded or other hardware changes are made. A section should be included in the programmer's guide to provide guidance on hardware-dependent programming. For example, the use of event triggers in place of timing loops will help make a piece of code independent of processor execution speed.

6. Expanding the Red Team Package

The Red Team Package, which provides procurement guidance for TPS developers, is an excellent concept and should be continued. It also provides a repository for critical guidance and lessons learned. All the CASS personnel we talked with agreed with our recommendations for the Style Guide and Red Team Package, and many of the items we've mentioned are already in process.

7. Strengthening the Role of the DGAR

As we have noted, many of the improvements we have suggested in TPS generation could be implemented by giving greater responsibility and authority to the DGARs who oversee the development of TPSs. We have suggested, for example, that the DGARs could be empowered to set restrictive policies in such areas as hardware-dependent programming and use of FEPs, and TPS developers could be required to obtain formal waivers from the DGARs to depart from these policies.

DGARs, for their part, could benefit from more training. Because of the number (over 7,000) and role of TPSs in testing Navy electronics, the generation of low-cost and efficient TPSs is clearly an important goal for Navy operations. DGARs therefore require a high level of sophistication to perform their functions well. Their tools are limited, and sometimes confusing. As an example, the current pattern of ESQA (Expert System Quality Analyzer) scoring rewards use of tight tolerances, but as we mentioned above, tight tolerances are not always desirable. Another problem is that DGARs do not always know the environment in which testing is being conducted. In Section 3, we discussed the

need for the establishment of a fault allocation table prior to PDR. Additional training for DGARs is therefore worthy of consideration by the Program Office.

8. Summary of Task 3

To reduce the cost and time of TPS development, we recommend that the Program Office take the following actions:

- Develop policies to minimize the use of hardware-dependent programming and FEPs. Promulgate the policies in the comprehensive style guide being developed by NAS Keyport.
- Implement a subset of the DO DIGITAL constructs, using the 1985 IEEE ATLAS language as listed in Table 2-7.
- Press for greater use of software tools (particularly simulations, the IDSS tool set, DICONS, and graphical displays) in developing TPSs. Promulgate a policy to encourage the use of existing tools in the comprehensive style guide and Red Team Package, and sponsor an effort to develop new tools.
- Give DGARs greater responsibility and authority to carry out the new policies regarding hardware-dependent programming, FEPs, and software tools. Establish a delivery schedule for items such as the fault allocation tables, which allow the DGARs to work out problems *before* final acceptance tests.

D. TASK 4: LONG-TERM ROADMAP

CASS software must respond to the recent changes in OSD policy regarding the use of commercial standards for testers, and a general move by industry toward more open architectures. These moves include the evolution of standards developed by the IEEE and other bodies.

The OSD policy statements are contained in two memoranda. The first, issued by the Under Secretary of Defense (Acquisition and Technology) on April 29, 1994, adopts measures to reverse the costly practice under which each program office that developed a new weapon system also developed a unique tester to service it. This practice resulted in a proliferation of testers and a duplication of the costs of development, spares, training, and other support.

The memorandum establishes the ATS as a separate commodity, names an Executive Agent (EA) to pass on major procurement questions, and approves the Navy's CASS and the Army's IFTE (Integrated Family of Test Equipment) as the two initial DoD families of testers. Program managers who develop new weapon systems must provide

some means for testing them. They have several alternatives: using one of the DoD families of test equipment, procuring a COTS tester (providing it has the necessary interfaces), or obtaining a waiver from the Executive Agent in order to develop a custom-designed tester.

The second OSD memorandum, issued by the Secretary of Defense on June 29, 1994, was intended to reduce the cost of all procurements (not just testers) by requiring the military Services to consider commercial, rather than military standards. The Services were to define their needs in terms of performance specifications rather than hardware systems to meet them, and then see if the requirements could be met by systems built according to commercial standards, rather than the current Military Standards (MilStds). The focus was thus shifted from Military Standards to COTS. The memorandum called for immediate implementation where possible, and authorized the reprogramming of funds to accomplish it. A Service would be required to obtain a waiver to continue to use Military Standards.

There does not exist, at present, a complete set of commercial standards for ATS software. COTS solutions are not currently allowed under the new ATS policy because the critical interfaces are not yet defined. Table 2-7 lists a number of standards under study and development. Although their use is indicated in some respects by the OSD memorandum, some of them are not practical for implementation in CASS.

Table 2-7 indicates those proposed standards that we recommend for the long-term roadmap, along with our rough estimate of when they will be available, and whether their impact is expected to be slight, moderate, or major. The standards are grouped by major type: ATLAS, ABBET, etc. For ease in reading, we have used a mixed notation that combines the common name with the IEEE designation. For example, ABBET 1226.1 is used to refer to the ABBET standard IEEE 1226.1.

The remainder of this section provides some technical discussion of the information in the table. This discussion is not intended for the general reader.

The ATLAS family of standards forms the basis for the test program language used by CASS. Two aspects are important. The DO DIGITAL constructs discussed earlier are present in all versions of ATLAS since 1985, and will be present in the next evolution of ATLAS, ATLAS-2000. The latter language will be tuned to concepts and techniques from ABBET, which can provide some important benefits to CASS.

Table 2-7. Long-Term Roadmap for CASS Software

IEEE Designation	Comments	Recommendations	Impact
ATLAS 1985/89.	Could be used for DO DIGITAL constructs.	Incorporate now	Slight
ATLAS 2000 (IEEE P716-2000)	A new Object/Resource-oriented and kernel-based language. Not expected to be available until 2000. It will use concepts from the ABBET upper and lower layers. It would need to be tested with one or more TPSs before acceptance for CASS.	Include in roadmap for 2002	Major
ABBET 1226 Overview and Architecture	In trial use.	Not recommended for CASS, except the Glossary of Terms should be followed	None
ABBET 1226.1 Common Ada Routines	In trial use.	Not applicable to CASS	None
ABBET 1226.2 ATLAS Language Test Procedure Interface	In trial use.	Not applicable to CASS	None
New ABBET 1226 Overview and Architecture	In draft. Applies to, and supplements the following standards: 1226.3, 1226.4, and 1226.5. Applies to CASS.	Must be implemented with the following standards: 1226.3, 1226.4, and 1226.5	Moderate
ABBET P1226.3 Test Equipment Interface	Exists in draft form only. Expected to go to ballot for trial use in May 1995. Should be used in conjunction with P1226.4 and P1226.5.	Include in roadmap for 1997	Moderate
ABBET P1226.4 Test Resource Interface	Exists in draft form only. Is expected to go to ballot for trial use in November 1995. Should be used in conjunction with P1226.3 and P1226.5.	Include in roadmap for 1998	Moderate
ABBET P1226.5 Bus Interface	Exists in draft form only. Expected to go to ballot for trial use in November 1995. It should be used in conjunction with P1226.3 and P1226.4.	Include in roadmap for 1997	Moderate
ABBET P1226.6 Introductory Guide	Exists in draft form only. Currently in ballot for trial use. Applicable to CASS, but is used for information only.	No action	None

Table 2-7. Long-Term Roadmap for CASS Software (Continued)

IEEE Designation	Comments	Recommendations	Impact
ABBET P1226.7 Test Product Data	Does not exist. Expected to go to ballot for trial use in May 1998. Not well defined for use in CASS.	No action	Unknown
ABBET P1226.8 Test Strategy/Requirements	Expected to go to ballot for trial use in May 1998. Not well enough defined for inclusion in Roadmap. (An exception is the Diagnostic Controller Concept, which is discussed under AIESTATE below.).	No action	Unknown
Ada-ATLAS IEEE 1446	In draft. Replaces old standards 1226, 1226.1, 1226.2 for Ada programming	Not applicable to CASS	
AIESTATE 1232 Overview and Architecture	In trial use. Not applicable to CASS	No action	
AIESTATE P1232.1 Data and Knowledge Representations	Exists in draft form only. Expected to go to ballot in November 1994. Applicable to the software environment as a member of the IDSS tool set. Has a standard fault tree representation, and includes the concept of diagnostic reasoner.	Include in Roadmap for 1997	Moderate
AIESTATE P1232.2 Reasoner Services	Drafts exist. Expected to go to ballot for trial use in May 1997 or later. Is applicable to CASS software in defining the diagnostic controller. CASS transition can begin with an encapsulated test approach with a fault tree controller when IEEE P1232.1 is available (possibly using the IDSS tools).	Include in Roadmap for 1999	Moderate
TMIMS P1389 Test and Maintenance Information Management Standard	Does not exist. Expected to go to ballot for trial use in May 1997 or later. Is applicable to CASS software for all maintenance data collection. Direct ties to NALCOMIS are required for applicability to CASS.	Include in Roadmap for 1999	Major

Table 2-7. Long-Term Roadmap for CASS Software (Continued)

IEEE Designation	Comments	Recommendations	Impact
Boundary Scan IEEE 1149.1 Test Access Port and Boundary Scan Architecture	Currently exists and is usable through the DTU. The Annex including the Boundary Scan Description Language is currently in ballot. It could be implemented in the CASS compiler with DO DIGITAL, but is otherwise inapplicable to CASS.	Include in the CASS compiler with DO DIGITAL	Slight
Boundary Scan IEEE P1149.5 System Level Boundary Scan	Exists in draft form only. Is not applicable to CASS.	No action	Moderate
Boundary Scan IEEE P1149.2-P1149.4	Currently in development.	No action	None
ATPG 1029.1 WAVES (Wave and Vector Exchange Standard (IEEE 1029.1).	Covers digital vector formats, but is less complete than TAP, which is compatible with the Teradyne DTU. The IEEE is standardizing on this format through a new initiative called DTIF, Digital Test Interface Format (IEEE 1445).	Use the IEEE DTIF standard. Use SDF as a recommended practice in the CASS program	None (Slight for DTIF)
ATPG 1029.2 FDL (Fault Dictionary Language, IEEE P1029.2).	Needed with WAVES. Is not complete.	No action	None
ATPG 1029.3 TRSL (Test Requirements Specification Language)	Not complete. Covers the same material as by ABBET 1226.8.	No action now. Reconsider when ABBET 1226.8 arrives	None
TEDL (Test Equipment Description Language, IEEE 993)	Covers the same material as ABBET 1226.3.	No action now. Reconsider when ABBET 1226.3 arrives	Slight
RDL (Resource Description Language, IEEE P981)	Covers the same material as ABBET 1226.4.	No action now. Reconsider when ABBET 1226.4 arrives	None

The first three standards in the ABBET family do not apply to CASS. These are being rewritten as IEEE 1446 Ada-ATLAS. They are restricted to Ada programming, and are not recommended for CASS. The Overview and Architecture standard is being rewritten to be language independent, and has elements that must be implemented with the 1226.3, 1226.4, and 1226.5 standards. It is expected that additional standards in this series will deal with resource development, and will be applicable to CASS as well.

The next three standards in the ABBET family do apply to CASS, and they deal with resource representation, hardware configuration bookkeeping, and instrument communication packages (which will replace the current BIC). These will probably be available for trial use form by 1996 and should be all or part of the same software release in 1998 or later.

The last three components of ABBET are mixed. The introductory guide is purely background material. The Test Product and Test Strategy documents have a large potential for application to CASS, but are so ill defined at this point that they cannot be included in the roadmap. Significant portions of the Test Strategy ABBET standards will probably refer to the AIESTATE standards discussed next.

AIESTATE standards apply to CASS in some degree, although the overview and architecture document is primarily for reference only. Trial use versions of the Data and Knowledge Representations should be available soon, and should be immediately prototyped in the IDSS tools. Reasoner services are available in draft form but will not be available in final form until 1997 or so. A complete CASS software release with AIESTATE compatibility should be available in the year 2000.

The TMIMS standard deals with maintenance data collection and applies to CASS, the CASS interface to NALCOMIS, and to NALCOMIS itself. A standard for trial use should be available in 1997, with a CASS software release in the 2000 timeframe.

BOUNDARY SCAN generally applies at the board level and can currently be addressed through L-200 code. If extensive use of Boundary Scan occurs at some future date, PMA-260 may wish to enforce ANNEX A—Boundary Scan Description Language—as a deliverable format. System Level Boundary Scan is evolving and may apply to WRA level, but it should be reviewed when the documents are produced.

TRSL (Test Requirement Specification Language) is not currently defined and will be covered by reference or incorporation in some of the ABBET standards. TEDLs (Test

Equipment Description Languages) and RDLs (Resource Description Languages) are subsumed by some of the ABBET standards, although they may refer to these standards explicitly, or incorporate portions of them. The ATPG (Automatic Test Program Generation) standards are not readily applied to CASS because the Teradyne DTU uses a DeFacto Standard format. Attempts are being made to raise this to the status of a commercial standard (DTIF), but failing that, there appears to be no advantage in going to WAVES (Wave and Vector Exchange Standard) and FDL (Fault Dictionary Language).

Figure 2-2 provides a time-phased picture of the recommendations made in Table 2-7. Implicit throughout the figure are the libraries of test methods, test resources, and other types of information used in performing actual tests. The most important thing to remember is that the roadmap must be flexible. IEEE standards are not precisely controllable in time or content. The figure illustrates the following:

- The test capabilities, shown in ovals, are the procedures that depend on product information, test specifications, and test methods.
- The tools, shown in boxes, provide descriptions of the resources—the instruments, power supplies, interfaces, and other assets needed to provide stimulus and measurement functions for tests. The tools also provide software for diagnostic strategy and code development. All of these items have been discussed previously, except for the browser tool. This tool will sort through the maintenance data collection databases looking for trends, unique events, and bad actors.
- The standards are shown in bold caps.
- The lines between the standards and the years show when the standards are predicted to be available in the prototype stage (shown by the thin line), and when they could be implemented into CASS (shown by the thick line). All standards should be prototyped before implementation. A suitable CASS system should probably be designated for this work and personnel currently working on the standards can begin prototype activities with the incorporation of the DO DIGITAL constructs previously described.

We recommend that the Navy undertake the steps listed below in deciding what new standards to accept for CASS implementation:

- Continue to participate in drafting SCC-20 standards.
- Evaluate each individual standard when issued by IEEE for trial use.

    Construct a test case.

    Run a demonstration program on the CASS system.

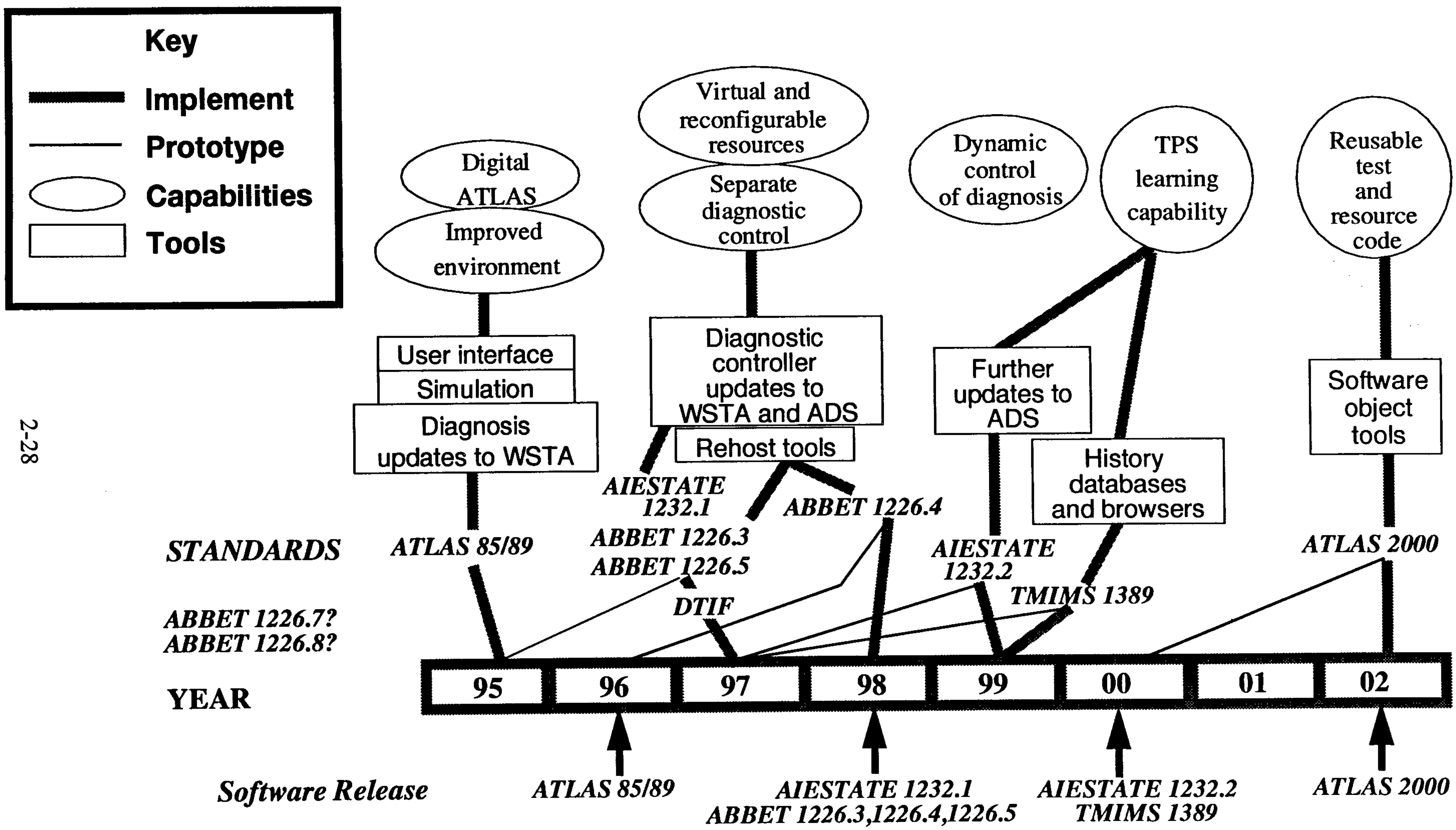

Figure 2.2. Illustration of Time-Phased Recommendations

- If the test is successful, press IEEE to issue a full use standard. Do not execute full implementation until this occurs.

Software releases are needed only every 2 years to accommodate the recommended roadmap.

III. SUMMARY OF PART 2

Our analysis under Task 1 shows that current software provides cross compatibility across different full CASS configurations (Hybrid, RF, CNI, EO), and upward compatibility from downsize to full CASS stations.

The analysis in Task 2 indicates that current software does not provide downward compatibility from full CASS to downsize CASS stations. However, by making minimum software changes to the station costing approximately $125,000, it will be possible to use multiple-application TPSs that will save much more than single-application TPSs in construction cost. These savings would be possible only for those TPSs yet to be placed under contract. Constructing multiple-application TPSs for UUTs for which single-application TPSs have already been developed would be costly backtracking.

Our discussion in Task 3 suggested that the Navy could improve TPS software by setting policies to accomplish the following:

- Restricting the use of hardware-dependent programming and FEPs to situations where their use is clearly worth the loss of configuration control.
- Adding digital capability to the ATLAS station through the DO DIGITAL constructs.
- Encouraging the use of existing tools and sponsoring the development of additional tools for developing TPSs.
- Adding sections regarding these topics to the style guide and Red Team Package.
- Strengthening the role of the DGARs.

Finally, Task 4 developed a long-term roadmap for upgrading CASS software to meet commercial standards newly called for by OSD, and for implementing some (but not all) of the new IEEE standards now under study and development. Changes suggested by the roadmap could be implemented by a cautious program of test and demonstration, followed by software releases at approximately 2-year intervals.

APPENDIX A

DETAILED DATA

This appendix lists the test requirements obtained from the SSM (System Synthesis Model) database vs. CASS capability (Tables A-1a through A-1g), and performance characteristics from the ECAC (Electromagnetic Compatibility Analysis Center) database (Table A-2).

Tables A-1a through A-1g list the SSM requirements data, including those figures that were obtained by the IDA study team and inserted into the SSM model. The characteristics shown in each table are listed below.

Table	Data
A-1a	Power Load
	RF Stimulus
	RF Power Measurement
A-1b	Pulse Generation
	Waveform Generation
A-1c (DMM requirements)	DC voltage
	DC current
	AC current
	Resistance
	AC voltage
A-1d	Digital Stimulus
	Digital Measurement
A-1e	UUT DC Power
	UUT AC Power
A-1f	Pulse Measurement
	Waveform Measurement
A-1g	Frequency Measurement
	Time Interval Measurement

The data in Table A-1 were used in Chapter II of Part 1 to identify the test characteristics for which CASS failed to meet a coverage of 85 percent. There are figures for 99 programs representing 1,232 UUTs: 746 for Navy aircraft, 130 for Navy ships, 282

for Marine aircraft, and 74 for Marine ground systems. The requirements are specified by 48 individual characteristics such as frequency, and grouped by 18 major test categories such as RF stimulus. (The SSM database lists 25 test categories, but only 18 were needed for the present analysis.) As mentioned in the text, the table entries are envelopes values, or maximum and minimum values for each test characteristic over all the WRAs and SRAs for each system.

The "E" column in Tables A-1a through g indicate the number of exceptions, or test requirements that lie outside of the current capability of CASS. (A "0" means CASS meets all requirements.) Summary statistics at the bottom of the tables indicate the total number of requirements for each characteristics, the maximum or minimum test requirement observed, and the percentage of the envelope requirements met.

The ECAC performance data, shown in Table A-2, were used as test requirements in the analysis of CASS improvements that is discussed in Chapter III of Part 1.

Table A-1a. RF Load, Stimuli, and Power Measurement Test Requirements and CASS Capability

	Resistive Load				RF Stimuli						RF Power Measurement					
	Resistance		Power		Frequency		Power				Frequency		Power			
	Max Ohms	E	Max Watts	E	Max Hz	E	Max dBm	E	Min dBm	E	Max Hz	E	Max dBm	E	Min dBm	E
CASS Capability	1.9E+07		500		4.0E+10		16.5		-100		5.0E+10		44		-140	
Navy Aircraft																
A-6	1.0E+06	0														
AV-8B (CIP)	5.0E+05	0	200	0												
AV-8B	5.0E+07	1	200	0												
EA-6B (CIP)	1.0E+03	0	20	0	9.9E+07	0	42	1	-53	0	1.7E+09	0	25	0	-20	0
F-14D (CIP)	1.0E+07	0	342	0	2.6E+10	0	12	0	-10	0	1.8E+10	0	21	0	-35	0
F-14D	1.0E+05	0	500	0	1.2E+08	0	1	0	-3	0	1.2E+08	0	22.5	0	-92	0
F/A-18 E/F (CIP)	7.5E+04	0	25	0												
S-3 Offload (CIP)	1.0E+06	0	6,000	2	1.5E+10	0	23	2	-60	0	1.3E+10	0	50	1	-64	0
S-3	3.8E+03	0	500	0	4.3E+09	0	0	0	0	0	4.3E+09	0	20	0	-54	0
SH-60 (CIP)																
Avionic (CIP)	1.5E+05	0	1,100	3	1.8E+10	0	87	3	-101	1	1.8E+10	0	38	0	-101	0
Avionics Offload (CIP)	1.2E+08	1	4,000	2	1.0E+10	0	30	2	-99	0	1.0E+10	0	87	1	-1.5	0
Avionics	5.1E+05	0	2,000	2	1.8E+10	0	40	4	-65	0	1.8E+10	0	86	3	-46	0
Extreme Value/Count	1.2E+08	38	6,000	35	2.6E+10	23	87	19	-101	20	1.8E+10	25	87	22	-101	21
Number Exceptions		2		9		0		12		1		0		5		0
Fraction Covered		0.9		0.7		1		0		1		1		1		1

Table A-1a. RF Load, Stimuli, and Power Measurement Test Requirements and CASS Capability (Continued)

	Resistive Load				RF Stimuli						RF Power Measurement					
	Resistance		Power		Frequency		Power				Frequency		Power			
	Max Ohms	E	Max Watts	E	Max Hz	E	Max dBm	E	Min dBm	E	Max Hz	E	Max dBm	E	Min dBm	E
CASS Capability	1.9E+07		500		4E+10		16.5		-100		5E+10		44		-140	
Navy Ships																
ACSSIS																
AN/BQQ-5	5,000	0	0.65	0												
AN/BQQ-9																
AN/SLQ-32					2.6E+10	0	99	1	5	0	2.7E+10	0	44	0	-70	0
AN/SQQ-89	2,200	0	270	0							5.0E+03	0	-50	0	-120	0
AN/USC-38					4.6E+10	1	8	0	8	0	4.6E+10	0	15	0	15	0
AN/UYQ-21																
AN/UYS-2																
CEC	50	0	200	0	8.0E+09	0	53	1	53	0	8.0E+09	0	53	1	53	0
HFRG (AN/URC-131)	50	0	4,000	1	3.0E+07	0	31.2	1	-109	1	7.2E+07	0	66	1	-67	0
HSFB (AN/USQ-122)					2.7E+08	0	-50	0	-125	1	7.0E+08	0	0	0	-125	0
MK-78	1.0E+05	0	256	0												
MK-116																
MK-117	1.0E+06	0														
MK-118																
MK-122	500	0	29	0												
MK-408																
Extreme Value/Count	1.0E+06	7	4,000	6	4.6E+10	5	99	5	-125	5	4.6E+10	6	66	6	-125	6
Number Exceptions		0		1		1		3		2		0		2		0
Fraction Covered		1		0.8		1		0		1		1		1		1

Table A-1a. RF Load, Stimuli, and Power Measurement Test Requirements and CASS Capability (Continued)

	Resistive Load				RF Stimuli						RF Power Measurement					
	Resistance		Power		Frequency		Power				Frequency		Power			
	Max Ohms	E	Max Watts	E	Max Hz	E	Max dBm	E	Min dBm	E	Max Hz	E	Max dBm	E	Min dBm	E
CASS Capability	1.9E+07		500		4.0E+10		16.5		-100		5.0E+10		44		-140	
Marine Corps Ground																
AN/MRC-142	350	0	157	0	1.9E+09	0	33	1	-15	0	1.9E+09	0	42	0	-25	0
AN/PPS-15A					1.1E+10	0	-80	0	-80	0	1.1E+10	0	17	0	-90	0
AN/TRC-170	50	0	100	0	5.0E+09	0					5.0E+09	0	50	1	50	0
AN/TSQ-129	48	0	47.5	0	4.5E+08	0	-46	0	-46	0	4.5E+08	0	50	1	-70	0
SCAMP					2.7E+10	0				0	4.4E+10	0	37	0	-30	0
SINCGARS	1.0E+05	0	150	0	8.8E+07	0	36	1	-15	0	5.0E+09	0	48	1	-3	0
Extreme Value/Count	1.0E+05	4	157	4	2.7E+10	6	36	4	-80	4	4.4E+10	6	50	6	-90	6
Number Exceptions		0		0		0		2		0		0		3		0
Fraction Covered		1		1		1		1		1		1		1		1
Marine Corps Aircraft																
AH-1W	50	0	23	0	4.3E+09	0	10	0	-53	0	1.8E+10	0	66	1	23	0
AV-8B	5.0E+05	0	84	0	1.0E+10	0	-53	0	-53	0	1.0E+10	0	44	0	5	0
CH-53E	50	0	23	0	4.0E+08	0	-53	0	-53	0	4.0E+08	0	44	0	23	0
EA-6B	1.0E+03	0	20	0	2.0E+10	0	42	1	-53	0	2.2E+10	0	25	0	-20	0
F/A-18 C/D	3.0E+04	0	545	1	1.0E+10	0					1.0E+10	0	13	0	5	0
F/A-18E/F	7.5E+04	0	25	0	1.0E+10	0					1.0E+10	0	13	0	13	0
KC-130T	50	0	23	0	1.6E+10	0	70.3	1	-102	1	9.4E+09	0	80	1	-102	0
MV-22	1.0E+04	0	23	0	1.6E+09	0	10	0	-74	0	1.8E+10	0	66	1	10	0
UH-1N	50	0	23	0	1.6E+09	0	0	0	-74	0	1.2E+09	0	66	1	23	0
Extreme Value/Count	5.0E+05	9	545	9	2.0E+10	9	70.3	7	-102	7	2.2E+10	9	80	9	-102	9
Number Exceptions		0		1		0		2		1		0		4		0
Fraction Covered		1		0.9		1		1		1		1		1		1

Table A-1a. RF Load, Stimuli, and Power Measurement Test Requirements and CASS Capability (Continued)

	Resistive Load				RF Stimuli						RF Power Measurement					
	Resistance		Power		Frequency		Power				Frequency		Power			
	Max Ohms	E	Max Watts	E	Max Hz	E	Max dBm	E	Min dBm	E	Max Hz	E	Max dBm	E	Min dBm	E
CASS Capability	1.9E+07		500		4.0E+10		16.5		-100		5.0E+10		44		-140	
Summary																
Navy Aircraft	1.2E+08	2	6,000	9	2.6E+10	0	87	12	-101	1	1.8E+10	0	87	5	-101	0
Navy Ships	1.0E+06	0	4,000	1	4.6E+10	1	99	3	-125	2	4.6E+10	0	66	2	-125	0
Marine Air	5.0E+05	0	545	1	2.0E+10	0	70.3	2	-102	1	2.2E+10	0	80	4	-102	0
Marine Ground	1.0E+05	0	157	0	2.7E+10	0	36	2	-80	0	4.4E+10	0	50	3	-90	0
Extreme Value/Count	1.2E+08	58	6,000	54	4.6E+10	43	99	35	-125	36	4.6E+10	46	87	43	-125	42
Number of Exceptions		2		11		1		19		4		0		14		0
Fraction Covered		1		0.8		1		0		1		1		1		1

Table A-1b. Pulse and Waveform Generation Test Requirements and CASS Capability

	Pulse Generation										Waveform Generation					
	Repetition Period				Pulse Width				Voltage		Frequency				Voltage	
	Max Sec	E	Min Sec	E	Max Sec	E	Min Sec	E	Max Volts	E	Max Hz	E	Min Hz	E	Max Volts	E
CASS Capability	100		4.0E-09		100		2.0E-09		10		2.50E+07		0.01		10	
Navy Aircraft																
A-6	0.017	0	2.2E-05	0	0.1	0	7.5E-08	0	8.50	0	4,000	0	30	0	32	2
AV-8B (CIP)	0.4	0	1.3E-07	0	3	0	1.0E-06	0	28	1	2.0E+07	0	1.0E-05	0	17.5	1
AV-8B	8.0E-05	0	1.3E-07	0	4.0E-05	0	4.0E-05	0	10	0	2.0E+07	0			10	0
EA-6B (CIP)	0.016	0	1.0E-04	0	4.0E-06	0	2.0E-07	0	13	1	8.0E+07	1	4,000	0	3	0
F-14D (CIP)	30	0	1.0E-11	1	1	0	1.3E-08	0	70	4	7.0E+10	1	8	0	155	4
F-14D	0.1	0	1.0E-06	0	0.05	0	5.0E-07	0	50	1	1.4E+06	0	420	0	28	3
F/A-18 E/F (CIP)											1.1E+04	0	80	0	10	0
S-3 Offload (CIP)	60	0	1.0E-08	0	10	0	4.0E-09	0	15	1	1.0E+06	0	50	0	100	2
S-3 (Non-CIP)	30	0	1.3E-08	0	3	0	6.0E-09	0	30	1						
SH-60 (CIP)	2.0E-06	0	2.0E-06	0	2.0E-06	0	2.0E-06	0	50	0						
Avionic (CIP)	1	0	1.2E-07	0	0.5	0	1.0E-11	1	50	1	6.9E+10	2	0.66	0	150	2
Avionics Offload (CIP)	0.1	0	1.7E-08	0	35	0	8.6E-09	0	12	2	1.0E+06	0	40	0	24	2
Avionics	50	0	1.0E-07	0	27	0	1.9E-08	0	60	6	3.0E+07	1	0.05	0	120	5
Extreme Value/Use Count	60	39	1.0E-11	39	35	40	1.0E-11	40	70	35	7.0E+10	43	1.0E-05	38	155	42
Number Exceptions		0		1		0		1		18		5		0		21
Fraction Covered		1.0		1.0		1.0		1.0		0.5		0.9		1.0		0.5

Table A-1b. Pulse and Waveform Generation Test Requirements and CASS Capability (Continued)

	Pulse Generation										Waveform Generation					
	Repetition Period				Pulse Width				Voltage		Frequency				Voltage	
	Max Sec	E	Min Sec	E	Max Sec	E	Min Sec	E	Max Volts	E	Max Hz	E	Min Hz	E	Max Volts	E
CASS Capability	100		4.0E-09		100		2.0E-09		10		2.5E+07		0.01		10	
Navy Ships																
ACSSIS											4.0E+03	0	16	0	5	0
AN/BQQ-5											8.7E+06	0	1.5	0	22	1
AN/BQQ-9	1.0E-06	0	1.0E-06	0	2.2E-08	0	2.2E-08	0	5	0						
AN/SLQ-32	0.95	0	2.0E-08	0	0.95	0	1.0E-08	0	16	1	1.0E+05	0	100,000	0		
AN/SQQ-89 (CIP)											5.7E+05	0	2,000	0	7.1	0
AN/USC-38	1.1E-07	0	1.1E-07	0	5.0E-10	0	5.0E-10	1	5.5	0						
AN/UYQ-21											800	0	800	0		
AN/UYS-2																
CEC (CIP)											1.0E+07	0	13,000	0		
HFRG (AN/URC/131)											5.0E+07	1	5	0	5	0
HSFB (AN/USQ/122)	1.0E-06	0	5.0E-07	0	5.0E-07	0	1.0E-07	0			3.8E+04	0	75	0		
MK-78	4.0E-08	0	4.0E-08	0	1.0E-08	0	1.0E-08	0	7.5	0						
MK-116											1.0E+05	0	400	0	5	0
MK-117																
MK-118																
MK-122															5	0
MK-408	5.0E-07	0	1.0E-07	0	1.0E-08	0	1.0E-08	0	5	0					1	0
Extreme Value/Use Count	0.95	6	2.0E-08	6	0.95	6	5.0E-10	6	16	5	5E+07	9	1.5	9	22	7
Number Exceptions		0		0		0		1		1		1		0		1
Fraction Covered		1.0		1.0		1.0		0.8		0.8		0.9		1.0		0.9

Table A-1b. Pulse and Waveform Generation Test Requirements and CASS Capability (Continued)

	Pulse Generation										Waveform Generation					
	Repetition Period				Pulse Width				Voltage		Frequency				Voltage	
	Max Sec	E	Min Sec	E	Max Sec	E	Min Sec	E	Max Volts	E	Max Hz	E	Min Hz	E	Max Volts	E
CASS Capability	100		4.0E-09		100		2.0E-09		10		2.5E+07		0.01		10	
Marine Corps Ground																
AN/MRC-142	1.7E-06	0	1.7E-06	0							5.8E+05	0	1,600	0	0.7	0
AN/PPS-15A	2.0E-07	0	2.0E-07	0	1.0E-07	0	1.0E-07	0	3	0	6.0E+05	0	25	0	0.75	0
AN/TRC-170																
AN/TSQ-129	2.0E-07	0	2.0E-07	0	1.90E-07	0	1.9E-07	0								
SCAMP											9.6E+03	0	9,600	0		
SINCGARS	1.0E-03	0	3.0E-07	0							3.8E+06	0	600	0	6.8	0
Extreme Value/Use Count	0.001	4	2.0E-07	4	1.9E-07	2	1.0E-07	2	3	1	3.8E+06	4	25	4	6.8	3
Number Exceptions		0		0		0		0		0		0		0		0
Fraction Covered		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0
Marine Corps Aircraft																
AH-1W	5.0E+01	0	1.0E-07	0	2.7E+01	0	1.9E-08	0	20	1	1.0E+07	0	30	0	20	1
AV-8B	0.4	0	6.4E-05	0	3	0	1.0E-06	0	29	1	1.0E+05	0	21	0	29	1
CH-53E					0.03	0	0.03	0			5.0E+04	0	1,000	0	6.5	0
EA-6B	0.016	0	0.0001	0	0.004	0	2.0E-07	0	13	1	8.0E+07	1	8.0E+07	0	10.5	1
F/A-18 C/D	0.2	0	4.0E-07	0	0.05	0	1.0E-11	1	6	0	2.0E+07	0	40	0	21	1
F/A-18E/F											1.1E+04	0	80	0	10	0
KC-130T	5.0E-03	0	5.0E-03	0	3.0E-02	0	5.0E-06	0	20	1	5.0E+04	0	20	0	26	1
MV-22	50	0	1.0E-07	0	27	0	5.0E-08	0	32	1	2.1E+07	0	0.66	0	29	1
UH-1N	0.007	0	0.006	0	0.03	0	3.5E-06	0			2.0E+07	0	0.66	0	6.5	0
Extreme Value/Use Count	50	7	1.0E-07	7	27	8	1.0E-11	8	32	6	8.0E+07	9	0.66	9	29	9
Number Exceptions		0		0		0		1		5		1		0		6
Fraction Covered		1.0		1.0		1.0		0.9		0.2		0.9		1.0		0.3

Table A-1b. Pulse and Waveform Generation Test Requirements and CASS Capability (Continued)

	Pulse Generation										Waveform Generation					
	Repetition Period				Pulse Width				Voltage		Frequency				Voltage	
	Max Sec	E	Min Sec	E	Max Sec	E	Min Sec	E	Max Volts	E	Max Hz	E	Min Hz	E	Max Volts	E
CASS Capability	100		4.0E-09		100		2.0E-09		1.0E+01		2.5E+07		0.01		10	
Summary																
Navy Aircraft	60	0	1.0E-11	1	35	0	1.0E-11	1	70	18	7.0E+10	5	1.0E-05	0	155	21
Navy Ships	0.95	0	2.0E-08	0	0.95	0	5.0E-10	1	16	1	5.0E+07	1	1.5	0	22	1
Marine Aircraft	50	0	1.0E-07	0	27	0	1.0E-11	1	32	5	8.0E+07	1	0.66	0	29	6
Marine Ground	0.001	0	2.0E-07	0	1.9E-07	0	1.0E-07	0	3	0	3.8E+06	0	25	0	6.8	0
Extreme Value/Use Count	60	56	1.0E-11	56	35	56	1.0E-11	56	70	47	7.0E+10	65	1.0E-05	60	155	61
Number of Exceptions		0		1		0		3		24		7		0		28
Fraction Covered		1		0.982		1		0.95		0.49		0.892		1		0.54

Table A-1c. Digital Multimeter Test Requirements and Capability

	DC Volts		DC Current		AC Current				Resistance		AC Volts			
	Max Volts	E	Max Amps	E	Max Amps	E	Max Hz	E	Max Ohms	E	Max Volts	E	Max Hz	E
CASS Capability	1,000		20		2		20,000		3.0E+07		700		1.0E+05	
Navy Aircraft														
A-6	28	0							1.0E+07	0	115	0	4,000	0
AV-8B (CIP)	2.5E+04	1	8	0	4.74	2	400	0	1.0E+06	0	123	0	400	0
AV-8B	25,000	1	3.8	0	2	0	400	0	1.0E+06	0	115	0	7.0E+04	0
EA-6B (CIP)	32	0	13.2	0							1.6	0	1.5E+06	1
F-14D (CIP)	1.5E+05	1	20.2	1					2.0E+07	0	15,000	1	3.3E+04	0
F-14D	1,420	1	13.5	0					1.0E+07	0	126.5	0	2400	0
F/A-18 E/F (CIP)	135	0	5.1	0			3,300	0	1.0E+07	0	7.7	0	3.5E+03	0
S-3 Offload (CIP)	575	0	125	1					1.0E+07	0	210	0	1.0E+08	1
S-3	500	0							1.0E+07	0	200	0	1.2E+03	0
SH-60 (CIP)	254	0	30	1					1.0E+06	0	27	0	3.0E+06	1
Avionic (CIP)	280	0	103	4					1.0E+07	0	130	0	6.0E+03	0
Avionics Offload (CIP)	1.8E+04	2	45	1					1.0E+07	0	135	0	1.2E+08	2
Avionics	1.9E+04	2	50	2					1.5E+07	0	525	0	7.4E+05	2
Extreme Value/Use Count	150,000	65	125	41	4.74	3	3,300	4	1.5E+07	49	15,000	43	1.2E+08	39
Number Exceptions		8		10		2		0		0		1		7
Fraction Covered		0.9		0.8		0.3		1.0		1.0		1.0		0.8

Table A-1c. Digital Multimeter Test Requirements and Capability (Continued)

	DC Volts		DC Current		AC Current				Resistance		AC Volts			
	Max Volts	E	Max Amps	E	Max Amps	E	Max Hz	E	Max Ohms	E	Max Volts	E	Max Hz	E
CASS Capability	1,000		20		2		20,000		3.0E+07		700		1.0E+05	
Navy Ships														
ACSSIS	5.5	0	0.05	0										
AN/BQQ-5	20	0	0.034	0							115	0	400	0
AN/BQQ-9	5.5	0	0.016	0										
AN/SLQ-32	1,000	0	2	0					20,000	0	700	0		
AN/SQQ-89 (CIP)	30	0	18	0					1.0E+08	1	7.5	0	2.0E+07	1
AN/USC-38	208	0	3	0							440	0	60	0
AN/UYQ-21	12	0	0.04	0										
AN/UYS-2	15	0												
CEC (CIP)	276	0												
HFRG (AN/URC-131)											0.22	0	5,000	0
HSFB (AN/USQ-122)	20	0							1,500	0	115	0	60	0
MK-78	60	0	0.1	0							1.2	0		
MK-116	5	0	0.2	0							25	0	4.0E+05	1
MK-117	30	0	0.45	0							20	0	400	0
MK-118	18	0	0.02	0							50	0	8.0E+04	0
MK-122	115	0	3	0							115	0	60	0
MK-408	28	0	0.11	0										
Extreme Value/Use Count	1,000	16	18	13					1E+08	3	700	11	2E+07	9
Number Exceptions		0		0						1		0		2
Fraction Covered		1.0		1.0						0.7		1.0		0.8

Table A-1c. Digital Multimeter Test Requirements and Capability (Continued)

	DC Volts		DC Current		AC Current				Resistance		AC Volts			
	Max Volts	E	Max Amps	E	Max Amps	E	Max Hz	E	Max Ohms	E	Max Volts	E	Max Hz	E
CASS Capability	1,000		20		2		20,000		3.0E+07		700		1.0E+05	
Marine Corps Ground														
AN/MRC-142	35	0	15	0	4	1	400	0			0.7	0	3,000	0
AN/PPS-15A	24	0	0.5	0					2.5E+02	0	6	0	2.4E+05	1
AN/TRC-170	28	0									208	0	400	0
AN/TSQ-129	28	0	9.5	0					1.0E+05	0				
SCAMP	33	0												
SINCGARS	200	0	10	0					1.6E+05	0	24.5	0	7.0E+05	1
Extreme Value/Use Count	200	6	15	4	4	1	400	1	1.6E+05	3	208	4	7.0E+05	4
Number Exceptions		0		0		1		0		0		0		2
Fraction Covered		1.0		1.0		0.0		1.0		1.0		1.0		0.5
Marine Corps Aircraft														
AH-1W	200	0	0.2	0					1.5E+07	0	141	0	1.0E+06	1
AV-8B	505	0	14	0	6	1	400	0	1.0E+06	0	123	0	1.0E+06	1
CH-53E	100	0	0.18	0					1.0E+05	0	7.5	0	1,000	0
EA-6B	10.5	0	13.2	0					1.0E+07	0	1.6	0	1.5E+06	1
F/A-18 C/D	260	0	102.8	1	6	1	400	0	1.0E+07	0	115	0	16,000	0
F/A-18E/F	135	0	5.1	0					1.0E+07	0	7.7	0	3,500	0
KC-130T	400	0	0.18	0					1.0E+08	1	7.5	0	1,000	0
MV-22	200	0	6.3	0					1.5E+07	0	140	0	1.0E+06	1
UH-1N	100	0	0.2	0					1.0E+05	0	102	0	1,000	0
Extreme Value/Use Count	505	9	102.8	9	6	2	400	2	1.0E+08	9	141	9	1.5E+06	9
Number Exceptions		0		1		2		0		1		0		4
Fraction Covered		1.0		0.9		0.0		1.0		0.9		1.0		0.6

Table A-1c. Digital Multimeter Test Requirements and Capability (Continued)

	DC Volts		DC Current		AC Current				Resistance		AC Volts			
	Max Volts	E	Max Amps	E	Max Amps	E	Max Hz	E	Max Ohms	E	Max Volts	E	Max Hz	E
CASS Capability	1,000		20		2		20,000		3.0E+07		700		1.0E+05	
Summary														
Navy Aircraft	150,000	8	125	10	4.74	2	3,300	0	1.5E+07	0	15,000	1	1.2E+08	7
Navy Ships	1,000	0	18	0	0	0	0	0	1.0E+08	1	700	0	2.0E+07	2
Marine Air	505	0	102.8	1	6	2	400	0	1.0E+08	1	141	0	1.5E+06	4
Marine Ground	200	0	15	0	4	1	400	0	1.6E+05	0	208	0	7.0E+05	2
Extreme Value/Use Count	150,000	96	125	67	6	6	3,300	7	1.0E+08	64	15,000	67	1.2E+08	61
Number of Exceptions		8		11		5		0		2		1		15
Fraction Covered		0.917		0.836		0.17		1		0.97		0.985		0.75

Table A-1d. Digital Stimulus and Measurements Test Requirements and Capability

	Digital Measurement										Digital Stimulus							
	Pin Quantity		Data Rate		Voltage				Drive		Pin Quantity		Data Rate		Voltage		Drive	
	Max No.	E	Max B/S	E	Max Volts	E	Min Volts	E	Min Amps	E	Max Pins	E	Max B/S	E	Max Volts	E	Max Amps	E
CASS Capability	336		4.0E+07		13.5		-5		1.2E-04		336		4.0E+07		15		0.05	
Navy Aircraft																		
A-6	278	0	8.0E+06	0	5	0					98	0	8.0E+06	0	28	1		
AV-8B (CIP)	164	0	2.0E+06	0	28	2	0	0	0.0016	0	184	0	5.0E+06	0	28	1	0.05	0
AV-8B	164	0	2.0E+07	0	28	1	0	0	0.02	0	66	0	2.0E+07	0	28	1	0.02	0
EA-6B (CIP)	148	0	1.0E+06	0	13.5	0	0.2	0	8.0E-06	1	120	0	2.5E+05	0	3.9	0	0.042	0
F-14D (CIP)	437	2	8.0E+06	0	28	1	1.85	0	0.005	0	360	1	1.0E+11	1	28	2	0.5	2
F-14D (Non CIP)	131	0	1.2E+07	0	80	2	4	0	1.00E-06	1	72	0	1.2E+07	0	28	3	1	1
F/A-18 E/F (CIP)	41	0	1.7E+02	0	31.5	1	-2	0	0.04	0	162	0	1.0E+06	0	31.5	1	0.2	1
S-3 Offload (CIP)	212	0	1.0E+07	0	11.5	0	1	0	.0016	0	253	0	1.0E+07	0	28	1	0.042	0
S-3	6	0	6.0E+06	0	5	0	0	0			2	0	6.0E+06	0	5	0		
SH-60 (CIP)	20	0	1.2E+05	0	5	0	0.2	0	0.1	0	2	0	1.3E+05	0	5	0	0.1	1
Avionic (CIP)	176	0	5.8E+07	1	29	5	2.5	0	2.0E-05	2	218	0	1.6E+08	2	29	3	0.3	4
Avionics Offload (CIP)	92	0	1.0E+07	0	28	2	-19	2			70	0	2.0E+06	0	28	1	0.0016	0
Avionics	129	0	4.0E+06	0	28	2	-4.0	0	0.016	0	129	0	4.0E+06	0	28	2	1.7	3
Extreme Value/Use Count	437	55	5.8E+07	48	80	50	19	50	1.0E-06	26	360	54	1E+11	44	31.5	52	1.7	29
Number Exceptions		2		1		16		2		4		1		3		16		12
Fraction Covered		1.0		1.0		0.7		1.0		0.8		1.0		0.9		0.7		0.6

Table A-1d. Digital Stimulus and Measurements Test Requirements and Capability (Continued)

	Digital Measurement										Digital Stimulus									
	Pin Quantity		Data Rate		Voltage				Drive		Pin Quantity		Data Rate		Voltage		Drive			
	Max No.	E	Max B/S	E	Max Volts	E	Min Volts	E	Min Amps	E	Max Pins	E	Max B/S	E	Max Volts	E	Max Amps	E		
CASS Capability	336		4.0E+07		13.5		-5		1.2E-04		336		4.0E+07		15		0.05			
Navy Ships																				
ACSSIS											97	0	1.0E+07	0	4	0	0.002	0		
AN/BQQ-5											31	0			4	0				
AN/BQQ-9															3.5	0	0.032	0		
AN/SLQ-32	128	0			5	0	0	0			128	0			5	0				
AN/SQQ-89 (CIP)	1,300	1	1.3E+07	0	5	0	0	0	0.03	0	36	0			5	0				
AN/USC-38	1.15E+02	0	2.4E+03	0	5.5	0	0	0	1.2E-02	0	112	0	2.4E+03	0	5.0	0	0.002	0		
AN/UYQ-21	5.20E+01	0	1.0E+07	0	3.5	0	0.4	0	1.6E-03	0	52	0	1.0E+07	0	5.0	0	0.04	0		
AN/UYS-2	134	0	2.0E+07	0	3.7	0	0	0	6.0E-02	0	800	0	2.0E+07	0	3.5	0	0.06	1		
CEC (CIP)	1,300	1	1.3E+07	0	5	0	0	0	0.03	0	8.0E+02	1	1.3E+07	0	5	0	0.03	0		
HFRG (AN/URC-131)																				
HSFB (AN/USQ-122)			3.8E+04	0									3.8E+04	0						
MK-78					6	0	-6	1	5.0E-03	0					11	0				
MK-116	4	0			3	0	0.2	0	0.0016	0	4.0	0	2.0E+07	0	3.5	0	0.08	1		
MK-117					30	1	-30	1			49	0	2.0E+07	0	14	0	0.006	0		
MK-118											70	0	1.0E+07	0	5	0	0.01	0		
MK-122											14	0			3.5	0	0.11	1		
MK-408															.5	0	0.025	0		
Extreme Value/Use Count	1,300	7	20,000,000	6	30	9	-30	9	0.0016	7	800	12	2.0E+07	9	14	15	0.11	11		
Number Exceptions		2		0		1		2		0		1		0		0		3		
Fraction Covered		0.7		1.0		0.9		0.8		1.0		0.9		1.0		1.0		0.7		

Table A-1d. Digital Stimulus and Measurements Test Requirements and Capability (Continued)

	Digital Measurement										Digital Stimulus							
	Pin Quantity		Data Rate		Voltage				Drive		Pin Quantity		Data Rate		Voltage		Drive	
	Max No.	E	Max B/S	E	Max Volts	E	Min Volts	E	Min Amps	E	Max Pins	E	Max B/S	E	Max Volts	E	Max Amps	E
CASS Capability	336		4.0E+07		13.5		-5		1.2E-04		336		4.0E+07		15		0.05	
Marine Corps Ground																		
AN/MRC-142	100	0	1.8E+07	0	12	0	-10	1			100	0	1.8E+07	0	16	1		
AN/PPS-15A															8	0		
AN/TRC-170			2.1E+06	0	5	0	-5	0					2.1E+06	0	5	0		
AN/TSQ-129	141	0			4.4	0	0	0			141	0			4.4	0		
SCAMP	34	0	9.6E+03	0		0		0			34	0	9.6E+03	0				
SINCGARS	152	0	3.8E+06	0	10	0	-10	1			152	0	3.2E+06	0	10	0		
Extreme Value/Use Count	152	4	1.8E+07	4	12	4	-10	4			152	4	1.8E+07	4	16	5		
Number Exceptions		0		0		0		2				0		0		1		
Fraction Covered		1.0		1.0		1.0		0.5				1.0		1.0		0.8		
MARINE CORPS AIRCRAFT																		
AH-1W	10	0	6.3E+04	0	15	1	0	0	6.0E-03	0	10	0	3.4E+06	0	7	0	0.025	0
AV-8B	107	0	2.0E+06	0	28	1	-19	1	6.0E-03	0	184	0	5.0E+06	0	28	1	0.3	1
CH-53E	10	0	6.3E+04	0	15	1	0	0	6.0E-03	0	10	0	1.0E+06	0	7	0	0.0031	0
EA-6B	148	0	1.0E+06	0	15	1	0	0	8.0E-06	1	120	0	1.0E+06	0	10.5	0		
F/A-18 C/D	92	0	2.1E+07	0	29	1	-19	1	1.0E-02	0	141	0	1.0E+07	0	29	1	0.3	1
F/A-18E/F	41	0	166	0	32	1	-2	0	4.0E-02	0	162	0	1.0E+06	0	31.5	1	0.2	1
KC-130T	20	0	6.3E+04	0	32	1	-9.75	1	6.0E-03	0	16	0	1.0E+06	0	28	1	0.0031	0
M V-22	58	0	5.0E+06	0	15	1	-5	0	2.5E-08	1	30	0	1.0E+06	0	99	1	0.067	1
UH-1N	10	0	6.3E+04	0	15	1	0	0			10	0	1.0E+06	0	7	0	0.003	0
Extreme Value/Use Count	148	9	2.1E+07	9	32	9	-19	9	2.5E-08	8	184	9	10,000,000	9	99	9	0.3	8
Number Exceptions		0		0		9		3		2		0		0		5		4
Fraction Covered		1.0		1.0		0.0		0.7		0.8		1.0		1.0		0.4		0.5

Table A-1d. Digital Stimulus and Measurements Test Requirements and Capability (Continued)

	Digital Measurement										Digital Stimulus							
	Pin Quantity		Data Rate		Voltage				Drive		Pin Quantity		Data Rate		Voltage		Drive	
	Max No.	E	Max B/S	E	Max Volts	E	Min Volts	E	Min Amps	E	Max Pins	E	Max B/S	E	Max Volts	E	Max Amps	E
CASS Capability	336[a]		4.0E+07		13.5		-5		1.2E-04		336[a]		4.0E+07		15		0.05	
Summary																		
Navy Aircraft	437	2	5.8E+07	1	80	16	-19	2	1.0E-06	4	360	1	1.0E+11	3	31.5	16	1.7	12
Navy Ships	1300	2	2.0E+07	0	30	1	-30	2	0.0016	0	800	1	2.0E+07	0	14	0	0.11	3
Marine Air	148	0	2.1E+07	0	32	9	-19	3	2.5E-08	2	184	0	1.0E+07	0	99	5	0.3	4
Marine Ground	152	0	1.8E+07	0	12	0	-10	2	0	0	152	0	1.8E+07	0	16	1	0	0
Extreme Value/Use Count	1,300	75	5.8E+07	67	80	72	-30	72	0	41	800	79	1.0E+11	66	99	81	1.7	48
Number of Exceptions		4		1		26		9		6		2		3		22		19
Fraction Covered		0.947		0.985		0.64		0.88		0.85		0.975		0.95		0.73		0.6

[a] 168 pins for data rates above 2E+07 bits per second.

Table A-1e. AC and DC Power Supply Test Requirements and CASS Capability

	DC Power				AC Power					
	Volts		Current		Volts		Current		Phases	
	Max Volts	E	Max Amps	E	Max Volts	E	Max Amps	E	Max No.	E
CASS Capability	450		115		200		30		3	
Navy Aircraft										
A-6	400	0	45	0	118	0	8.7	0	3	0
AV-8B (CIP)	550	1	10.4	0	127	0	9	0	3	0
AV-8B	240	0	10.4	0	120	0	4	0	3	0
EA-6B (CIP)	30	0	36.2	0	215	1	20	0	3	0
F-14D (CIP)	1,500	1	24	0	128	0	20	0	3	0
F-14D	41	0	20	0	125	0	40	1	3	0
F/A-18 E/F (CIP)	135	0	7	0	115	0	0.65	0	3	0
S-3 Offload (CIP)	1,500	1	65	0	210	1	50	2	3	0
S-3	28	0	5	0	200	0	20	0	3	0
SH-60 (CIP)	254	0	2	0	180	0	20	0	3	0
Avionic (CIP)	300	0	100	0	400	1	10	0	3	0
Avionics Offload (CIP)	20,000	3	35	0	135	0	60	1	3	0
Avionics	600	1	12	0	200	0	60	1	3	0
Extreme Value/Use Count	20,000	65	100	59	400	57	60	51	3	44
Number Exceptions		7		0		3		5		0
Fraction Covered		0.9		1.0		0.9		0.9		1.0

Table A-1e. AC and DC Power Supply Test Requirements and CASS Capability (Continued)

	DC Power				AC Power					
	Volts		Current		Volts		Current		Phases	
	Max Volts	E	Max Amps	E	Max Volts	E	Max Amps	E	Max No.	E
CASS Capability	450		115		200		30		3	
Navy Ships										
ACSSIS	15	0	0.8	0						
AN/BQQ-5	45	0	0.5	0						
AN/BQQ-9	12.5	0	0.01	0						
AN/SLQ-32	68	0	10	0	115	0			3	0
AN/SQQ-89 (CIP)	27	0	200	1	132	0	60	1	3	0
AN/USC-38	208	0	3	0	440	1	26.1	0	6	1
AN/UYQ-21	30	0	1.3	0						
AN/UYS-2	26	0	15	0	115	0			3	0
CEC (CIP)	276	0	25	0	440	1	40	1	3	0
HFRG (AN/URC-131)										
HSFB (AN/USQ-122)	20	0	108	0	115	0			1	0
MK-78	15	0	2	0	57	0			1	0
MK-116	7.5	0	3	0						
MK-117	35	0	1	0						
MK-118	30	0	1.1	0	115	0			1	0
MK-122	30	0	1.6	0	115	0	0.0075	0	1	0
MK-408	5	0	0.8	0						0
Extreme Value/Use Count	276	16	200	16	440	9	60	4	6	9
Number Exceptions		0		1		2		2		1
Fraction Covered		1.0		0.9		0.8		0.5		0.9

Table A-1e. AC and DC Power Supply Test Requirements and CASS Capability (Continued)

	DC Power				AC Power					
	Volts		Current		Volts		Current		Phases	
	Max Volts	E	Max Amps	E	Max Volts	E	Max Amps	E	Max No.	E
CASS Capability	450		115		200		30		3	
Marine Corps Ground										
AN/MRC-142	35	0	15	0	117.5	0	4	0	1	0
AN/PPS-15A	24	0	0.03	0						
AN/TRC-170	28	0			208	1			3	0
AN/TSQ-129	31.5	0	9.5	0						
SCAMP	26.5	0			220	1				
SINCGARS	200	0	10	0						
Extreme Value/Use Count	200	6	15	4	220	3	4	1	3	2
Number Exceptions		0		0		2		0		0
Fraction Covered		1.0		1.0		0.3		1.0		1.0
Marine Corps Aircraft										
AH-1W	110	0	13	0	118	0	0.7	0	1	0
AV-8B	550	1	17.1	0	115	0	15	0	3	0
CH-53E	110	0	5.4	0	28	0				
EA-6B	30	0	36.2	0	215	1	20	0	3	0
F/A-18 C/D	150	0	41.9	0	125	0			3	0
F/A-18E/F	135	0	7	0	115	0	0.65	0	3	0
KC-130T	300	0	10	0	115	0	10.5	0	1	0
MV-22	290	0	12.9	0	124	0	42	1	3	0
UH-1N	162	0	5.4	0	118	0	4	0	1	0
Extreme Value/Use Count	550	9	41.9	9	215	9	42	7	3	8
Number Exceptions		1		0		1		1		0
Fraction Covered		0.9		1.0		0.9		0.9		1.0

Table A-1e. AC and DC Power Supply Test Requirements and CASS Capability (Continued)

	DC Power				AC Power					
	Volts		Current		Volts		Current		Phases	
	Max Volts	E	Max Amps	E	Max Volts	E	Max Amps	E	Max No.	E
CASS Capability	450		115		200		30		3	
Summary										
Navy Aircraft	20,000	7	100	0	400	3	60	5	3	0
Navy Ships	276	0	200	1	440	2	60	2	6	1
Marine AIR	550	1	41.9	0	215	1	42	1	3	0
Marine Ground	200	0	15	0	220	2	4	0	3	0
Extreme Value/Use Count	20,000	96	200	88	440	78	60	63	6	63
Number of Exceptions		8		1		8		8		1
Fraction Covered		0.917		0.989		0.9		0.873		0.98

Table A-1f. Pulse and Waveform Measurement Test Requirements and CASS Capability

	Pulse Measurement										Waveform Measurement					
	Repetition Period				Pulse Width				Voltage		Frequency				Voltage	
	Max Sec	E	Min Sec	E	Max Sec	E	Min Sec	E	Min Volts	E	Max Hz	E	Min Hz	E	Min Volts	E
CASS Capability	50		3.8E-11		50		3.8E-11		1.00E-04		2.7E+10		0.03		3.5E-05	
Navy Aircraft																
A-6	0.033	0	2.0E-05	0	0.017	0	17E-07	0	0.2	0	25,000	0	30	0	1.5	0
AV-8B (CIP)	0.5	0	0.5	0	3	0	1.0E-06	0	0.5	0	1.0E+06	0	400	0	0.1	0
AV-8B					3.0E-05	0	1.0E-06	0	-5.0	0					3.9	0
EA-6B (CIP)	2.0E-04	0	1.0E-07	0	1.3E-04	0	3.0E-07	0	1.2	0	2.0E+05	0	2.0E+05	0		
F-14D (CIP)	2.00	0	1.5E-11	1	3	0	2.5E-09	0	1.7	0	6.0E+06	0	1.0	0	0.1	0
F-14D	0.055	0	2.0E-06	0	0.21	0	3.3E-07	0	6.0	0	1.6E+04	0	1.6E+04	0	0.9	0
F/A-18 E/F (CIP)	0.5	0	0.5	0	0.4	0	0.4	0	28	0	6.3E+03	0	6.3E+03	0	7	0
S-3 Offload (CIP)	2	0	5.0E-09	0	0.6	0	5.0E-08	0	15	0	2.6E+07	0	5.0	0	0.2	0
S-3											2.5	0	2.5	0	3.8	0
SH-60 (CIP)	2.0E-06	0	2.0E-06	0	2.0E-06	0	2.0E-06	0	0.5	0						
Avionic (CIP)	32	0	2.5E-09	0	32	0	4.1E-09	0	0.2	0	5.8E+07	0	21	0	0.005	0
Avionics Offload (CIP)	0.017	0	4.4E+07	0	0.04	0	6.0E-08	0	0.07	0	2.0E+05	0	110	0	3.5	0
Avionics	0.1	0	1.0E-06	0	0.075	0	1.9E-08	0	0.6	0	2.5E+07	0	5.0	0	0.05	0
Extreme Value/Use Count	32	35	1.5E-11	35	32	35	2.5E-09	34	-5.0	12	5.8E+07	35	1	34	0.005	34
Number Exceptions		0		1		0		0		0		0	1	0		0
Fraction Covered		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0

Table A-1f. Pulse and Waveform Measurement Test Requirements and CASS Capability (Continued)

	Pulse Measurement										Waveform Measurement					
	Repetition Period				Pulse Width				Voltage		Frequency				Voltage	
	Max Sec	E	Min Sec	E	Max Sec	E	Min Sec	E	Min Volts	E	Max Hz	E	Min Hz	E	Min Volts	E
CASS Capability	50		3.8E-11		50		3.8E-11		1.00E-04		2.7E+10		0.03		3.5E-05	
Navy Ships																
ACSSIS											2.0E+07	0	4.9	0	5	0
AN/BQQ-5											8.7E+06	0	8.7E+06	0	6.9	0
AN/BQQ-9																
AN/SLQ-32	6.0E-04	0	4.7E-04	0	1.0E-06	0	4.0E-07	0	5	0	2.2E+10	0	1.0	0		
AN/SQQ-89 (CIP)											1.0	0	1.0	0		
AN/USC-38																
AN/UYQ-21											4,000	0	4,000	0		
AN/UYS-2																
CEC (CIP)																
HFRG (AN/URC-131)											3.0E+07	0	1,400	0		
HSFB (AN/USQ-122)											7.0E+07	0	7.0E+07	0		
MK-78	1.4E-07	0	1.4E-07	0					0.5	0						
MK-116																
MK-117											410	0	20	0	1	0
MK-118																
MK-122																
MK-408																
Extreme Value/Use Count	6E-04	2	1.4E-07	2	1.0E-06	1	4.0E-07	1	0.5	2	2.2E+10	8	1	8	1	3
Number Exceptions		0		0		0		0		0		0		0		0
Fraction Covered		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0

Table A-1f. Pulse and Waveform Measurement Test Requirements and CASS Capability (Continued)

	Pulse Measurement										Waveform Measurement					
	Repetition Period				Pulse Width				Voltage		Frequency				Voltage	
	Max Sec	E	Min Sec	E	Max Sec	E	Min Sec	E	Min Volts	E	Max Hz	E	Min Hz	E	Min Volts	E
CASS Capability	50		3.8E-11		50		3.8E-11		1.00E-04		2.7E+10		0.03		3.5E-05	
Marine Corps Ground																
AN/MRC-142											1.80E+07	0	10,000	0	16	0
AN/PPS-15A	3.0E-06	0	3.0E-06	0	1.5E-06	0	1.5E-06	0	5.0	0						
AN/TRC-170																
AN/TSQ-129	2.0E-07	0	2.0E-07	0	1.9E-07	0	1.9E-07	0								
SCAMP											2.2E+10	0	2.2E+10	0		
SINCGARS											8.8E+07	0	1.0	0	5.0E-07	1
Extreme Value/Use Count	3.0E-06	2	2.0E-07	2	1.5E-06	2	1.9E-7	2	5	1	2.2E+10	3	1.0	3	5.0E-07	2
Number Exceptions		0		0		0		0		0		0		0		1
Fraction Covered		1.0		1.0		1.0		1.0		1.0		1.0		1.0		0.5
Marine Corps Aircraft																
AH-1W	4.0E-02	0	1.0E-06	0	1,800	0	1.9E-08	0	2.5	0	2.5E+07	0	20,000	0	0.7	0
AV-8B	5.0E-01	0	0.42	0	3	0	0.017	0			1.0E+06	0	400	0	0.1	0
CH-53E											5.0E+04	0	50,000	0	0.7	0
EA-6B	5.0E-04	0	1.0E-07	0	1.3E-04	0	3.0E-07	0	1.2	0	2.0E+05	0	2.0E+05	0	10.5	0
F/A-18 C/D	0.11	0	8.0E-06	0	0.25	0	4.1E-09	0	2.4		4.0E+07	0	1,000	0	1.5	0
F/A-18E/F	0.5	0	0.5	0	0.4	0	0.4	0			6.2E+03	0	6,200	0	7	0
KC-130T	5,000	1	7.0E-05	0	0.18	0	1.0E-06	0	2.0		5.0E+04	0	20	0	0.1	0
MV-22	2.7	0	1.0E-07	0	2	0	1.0E-07	0	2.5	0	2.5	0	12	0	0.63	0
UH-1N	0.04	0	0.0067	0	3.5E-06	0	3.5E-06	0			5.0E+04	0	50,000	0	0.7	0
Extreme Value/Use Count	5,000	8	1.0E-07	8	3	8	4.1E-09	8	1.2	5	4E+07	9	12	9	0.1	9
Number Exceptions		1		0		0		0		0		0		0		0
Fraction Covered		0.9		1.0		1.0		1.0		1.0		1.0		1.0		1.0

Table A-1f. Pulse and Waveform Measurement Test Requirements and CASS Capability (Continued)

	Pulse Measurement										Waveform Measurement					
	Repetition Period				Pulse Width				Voltage		Frequency				Voltage	
	Max Sec	E	Min Sec	E	Max Sec	E	Min Sec	E	Min Volts	E	Max Hz	E	Min Hz	E	Min Volts	E
CASS Capability	50		3.8E-11		50		3.8E-11		1.00E-04		2.7E+10		0.03		3.5E-05	
Summary																
Navy Aircraft	32	0	1.5E-11	1	32	0	2.5E-09	0	-5	0	5.8E+07	0	1	0	0.005	0
Navy Ships	6E-04	0	1.4E-07	0	1.0E-06	0	4.0E-07	0	0.5	0	2.2E+10	0	1	0	1	0
Marine AIR	5,000	1	1.0E-07	0	3	0	4.1E-09	0	1.2	0	4.0E+07	0	12	0	0.1	0
Marine Ground	3E-06	0	2.0E-07	0	1.5E-06	0	1.9E-07	0	5	0	2.2E+10	0	1	0	5.0E-07	1
Extreme Value/Use Count	5,000	47	1.5E-11	47	32	46	2.5E-09	45	-5	20	2.2E+10	55	1	54	5.0E-07	48
Number of Exceptions		1		1		0		0		0		0		0		1
Fraction Covered		0.97 9		0.97 9		1		1		1		1		1		0.98

Table A-1g. Frequency and Time Interval Measurement Test Requirements and CASS Capability

	Frequency Measurement				Time Interval Measurement					
	Frequency		Voltage		Time Interval				Voltage	
	Max Hz	E	Min Volts	E	Max Sec	E	Min Sec	E	Min Volts	E
CASS Capability	2.7E+10		0.035		1.5E+04		4.0E-09		0.035	
Navy Aircraft										
A-6	8.0E+06	0	5.0	0						
AV-8B (CIP)	4.0E+07	0	4.1E-04	1	520	0	6.9E-06	0	0.05	0
AV-8B	4.0E+07	0	-9.0	0	520	0	520	0	0.4	0
EA-6B (CIP)					0.23	0	1.3E-08	0	1	0
F-14 (CIP)	7.0E+07	0	5.0	0	98	0	5.0E-07	0	0.3	0
F-14D (Non CIP)	3.3E+08	0			11	0	0.02	0	2	0
F/A-18 E/F (CIP)										
S-3 Offload (CIP)	1.7E+08	0	0.1	0	60	0	7.8E-09	0	0.23	0
S-3					260	0	3.0	0	1	0
SH-60 (CIP)	3.0E+06	0								
Avionic (CIP)	1.6E+09	0	3.9	0	250	0	4.0E-08	0	0.02	1
Avionics Offload (CIP)	5.8E+07	0	5.0	0	90	0	1.3E-07	0	0.035	0
Avionics	1.2E+09	0	0.04	0	30	0	1.0E-09	1	0.02	2
Extreme Value/Use Count	1.6E+08	33	-9.0	22	520	29	1E-09	30	0.02	24
Number Exceptions		0		1		0		1		3
Fraction Covered		1.0		1.0		1.0		1.0		0.9

Table A-1g. Frequency and Time Interval Measurement Test Requirements and CASS Capability (Continued)

	Frequency Measurement				Time Interval Measurement					
	Frequency		Voltage		Time Interval				Voltage	
	Max Hz	E	Min Volts	E	Max Sec	E	Min Sec	E	Min Volts	E
CASS Capability	2.7E+10		0.035		1.5E+04		4.0E-09		0.035	
Navy Ships										
ACSSIS										
AN/BQQ-5										
AN/BQQ-9					2.0E-08	0	1.0E-08	0	2.4	0
AN/SLQ-32	2.0E+10	0	0.007	1	0.001	0	1.0E-07	0		
AN/SQQ-89 (CIP)	1.1E+11	1			0.004	0	3.5E-08	0	1	0
AN/USC-38	4.6E+10	1								
AN/UYQ-21										
AN/UYS-2										
CEC (CIP)										
HFRG (AN/URC-131)	3.0E+07	0			0.04	0	0.002	0		
HSFB (AN/USQ-122)	7.0E+08	0								
MK-78										
MK-116										
MK-117										
MK-118										
MK-122										
MK-408										
Extreme Value/Use Count	1.1E+11	5	0.007	1	0.04	4	1.0E-08	4	1	2
Number Exceptions		2		1		0		0		0
Fraction Covered		0.6		0.0		1.0		1.0		1.0

Table A-1g. Frequency and Time Interval Measurement Test Requirements and CASS Capability (Continued)

	Frequency Measurement				Time Interval Measurement					
	Frequency		Voltage		Time Interval				Voltage	
	Max Hz	E	Min Volts	E	Max Sec	E	Min Sec	E	Min Volts	E
CASS Capability	2.7E+10		3.5E-02		1.5E+04		4.0E-09		0.035	
Marine Corps Ground										
AN/MRC-142	1.9E+09	0	0.7	0						
AN/PPS-15A	1.1E+10	0			4.0E-08	0	4.0E-08	0		
AN/TRC-170	5.0E+09	0								
AN/TSQ-129	4.5E+08	0								
SCAMP	4.4E+10	1								
SINCGARS	8.8E+07	0	1.6E+01	0						
Extreme Value/Use Count	4.4E+10	6	0.7	2	4E-08	1	4.0E-08	1		
Number Exceptions		1		0		0		0		
Fraction Covered		0.8		1.0		1.0		1.0		
Marine Corps Aircraft										
AH-1W	1.0E+06	0	2.0E+02	0	3.0E+01	0	2.1E-07	0	100	0
AV-8B	1.2E+08	0	9.0E+00	0	1.6E+01	0	6.9E-06	0	1	0
CH-53E										
EA-6B					2.3E-01	0	1.3E-08	0	1	0
F/A-18 C/D	2.3E+10	0	2.5E-01	0	9.0E+01	0	1.6E-07	0	4.5	0
F/A-18E/F										
KC-130T	2.0E+04	0			2.0E+00	0	4.6E-04	0		
V-22	1.6E+09	0	1.1E-01	0	3.0E+01	0	0.04	0	0.01	1
UH-1N	1.60E+09	0			4.00E-02	0	0.04	0		
Extreme Value/Use Count	2.3E+10	6	1.1E-01	4	90	7	1.3E-08	7	0.01	5
Number Exceptions		0		0		0		0		1
Fraction Covered		1.0		1.0		1.0		1.0		0.8

Table A-1g. Frequency and Time Interval Measurement Test Requirements and CASS Capability (Continued)

	Frequency Measurement				Time Interval Measurement					
	Frequency		Voltage		Time Interval				Voltage	
	Max Hz	E	Min Volts	E	Max Sec	E	Min Sec	E	Min Volts	E
CASS Capability	2.7E+10		0.035		15,000		4.0E-09		0.035	
Summary										
Navy Aircraft	1.6E+09	0	-9	1	520	0	1.0E-09	1	0.02	3
Navy Ships	1.1E+11	2	0.007	1	0.04	0	1.0E-08	0	1	0
Marine Air	2.3E+10	0	0.11	0	90	0	1.3E-08	0	0.01	1
Marine Ground	4.4E+10	1	0.7	0	4E-08	0	4.0E-08	0	0	0
Extreme Value/Use Count	1.1E+11	50	-9	29	520	41	1.0E-09	42	0	31
Number of Exceptions		3		2		0		1		4
Fraction Covered		0.94		0.93		1		0.98		0.87

Table A-2. ECAC System Performance Data

Reference Number	Nomenclature	Mission	Platform	Frequency (Mhz)	Peak Power (kW)	Average Power (kW)	Band Use	Pulse Width (usec)	Pulse Rate (pps)	Sensitivity (dBm)	Noise Figure (dB)	Doppler Phase Det. ?	System Function
Air Force													
A93	AN/ARN-131	CNI	C-130H, MC-130E	0.01			R			-105			OMEGA
A96	AN/ARN-148	CNI	CH-46E	0.01			R						OMEGA
A118	AN/ARN-99	CNI	P-3C	0.01			R			-113			OMEGA
A137	LTN211 LIT	CNI	E-6A, KC-130T, P-3C, CH-46E, MH-53E	0.03			R			-60			OMEGA
A121	AN/ARR-85	CNI	B-1B	0.06			R			-138			Data/Emergency
A117	AN/ARN-92(V)	CNI	AC-130A	0.10			R			-113			LORAN
A103	AN/ARN-59(V)	CNI	CH-46D/E	1.75			R			-100.97			Radio Comm/Nav/DF
A104	AN/ARN-6	CNI	AC-130A/H	1.75			R			-97.4			Homing/Comm/Location/Nav/DF
A107	AN/ARN-83	CNI	P-3C, S-3B	1.75			R			-103			DF/Homing/Monitor/Nav
A106	AN/ARN-81	CNI	P-3C	1.95			R			-93			Loran
A113	AN/ARN-89	CNI	UH-1N	3.00			R			-93			DF
A114	AN/ARN-89A	CNI	MH-53E	3.00			R			-93			DF
A115	AN/ARN-89B	CNI	AH-1W	3.00			R			-93			DF
A61	AN/ARC-102	CNI	UH-1N	29.99	0.125	0.125	C			-107			Radio Comm
A62	AN/ARC-105	CNI	EA-6B	29.99	0.4	0.4	C			-107			Radio Comm
A71	AN/ARC-161	CNI	P-3C	29.99	1	1	C			-107			Comm/Radio Comm
A75	AN/ARC-165	CNI	E-3B/C	29.99	1	1	C			-107			Radio Comm/Data
A79	AN/ARC-174A(V)	CNI		29.99	0.1	0.1	C			-110.1			Radio Comm
A83	AN/ARC-199	CNI	EA-6B	29.99	0.15	0.15	C			-107			Radio Comm/Data
A85	AN/ARC-211	CNI	B-2A	29.99	0.4	0.4	C						Radio Comm
A119	AN/ARQ-34	CNI	E-2C	29.99	1	1	C						Radio Comm/Data
A4	51S1B COL	CNI	MC-130E	30.00			R			-111			Radio Comm
A65	AN/ARC-142	CNI	P-3C	30.00	1	1	C			-107			Radio Comm
A67	AN/ARC-153	CNI	S-3B	30.00	1	1	C			-116			Radio Comm/Data
A7	51Z3 COL	CNI	MC-130E	75.00			R			-61			Beacon
A8	51Z4 COL	CNI	E-8A JSTARS	75.00			R			-61			Beacon
A91	AN/ARN-12	CNI	KC-135A	75.00			R			-53			Nav
A100	AN/ARN-32	CNI	B-52G, KC-135A/D/E/Q/R, P-3C	75.00			R			-53			Beacon
A138	MKA 28D BEN	CNI	E-3B/C	75.00			R			-63			Radio Comm/Beacon
A63	AN/ARC-114	CNI	E-3B/C, UH-1N	75.95	0.01	0.01	C			-118			Homing/Secure Vox/Radio Comm
A78	AN/ARC-173	CNI	E-3B/C	76.00	0.01	0.01	C			-118			Radio Comm
A1	51R6 COL	CNI	KC-135 A/D/E/Q/R	117.90			R			-98			Nav/ILS
A94	AN/ARN-14	CNI	B-52G	135.90			R			-98			Radio Comm/Nav/ILS/Vor
A64	AN/ARC-115	CNI	UH-1N	149.97	0.015	0.015	C/R			-98			Comm/Radio Comm/Homing/DF
A76	AN/ARC-166	CNI	E-3B/C	149.97	0.025	0.025	C			-106			Radio Comm
A60	AN/ARC-101	CNI	P-3C	151.95	0.025	0.025	R/T			-97.5			Comm/Nav/ILS
A112	AN/ARN-87(V)	CNI	P-3C	151.95			R			-97.5			Nav/Radio Comm
A81	AN/ARC-186(V)	CNI	A-10A, AC-130A/H, B-52G, C-5B, C-17A, C-130H, E-8A, F-16C/D, KC-130T, KC-135A/R, MC-130E/H, CH-46D/EUH-1N	151.97	0.04	0.04	C/R			-116	9		Radio Comm/Data/Secure Vox
A120	AN/ARR-72(V)	CNI	P-3C	173.50			R			-113			Telemetry/Radio Comm
A122	AN/ARS-3	CNI	P-3C	173.50			R			-111			Sonobuoy
A140	R-1047AA	CNI	P-3C	173.50			R			-115	12		Beacon/Guidance/Radio Comm
A131	AN/PRT-5	CNI	KC-130T, P-3C	243.00	0.005	0.005	T						Beacon
A133	AN/URT-26(V) 1	CNI	P-3C	243.00	0.00025	0.00025	T						Beacon/Radio Comm
A134	AN/URT-26(V) 11	CNI	P-3C	243.00	0.00025	0.00025	T						Beacon/Radio Comm
A135	AN/URT-33A	CNI	A-6E, EA-6B, F-14D, F/A-18C/D, S-3B, AV-8B	243.00	0.0002	0.0002	T						Beacon/Emerg
A123	AN/ARS-6(V) 1	CNI	A-10A, AC-130H, MC-130E	300.00	0.01	0.01	C			-115	6		Radio Comm/Loc Other/Homing

Table A-2. ECAC System Performance Data (Continued)

Reference Number	Nomenclature	Mission	Platform	Frequency (Mhz)	Peak Power (kW)	Average Power (kW)	Band Use	Pulse Width (usec)	Pulse Rate (pps)	Sensitivity (dBm)	Noise Figure (dB)	Doppler Phase Det. ?	System Function
A86	AN/ARC-216	CNI	P-3C	318.00	0.1	0.1	R/T			-114	14		Radio Comm/Data/Satellite
A99	AN/ARN-31	CNI	B-52G	325.00			R			-87	12		Nav/ILS
A130	AN/ASW-25	CNI		325.00			R			-101			Data/Nav
A142	RT-1379 ASW	CNI	F/A-18C/D	325.00	0.015	0.015	C			-103.2			Radio Comm
A2	51RV1 COL	CNI	E-8A JSTARS	335.00			R			-98			Nav/Vor/ILS
A3	51RV2B COL	CNI	E-3B AWACS	335.00			R			-98			Nav/ILS
A5	51V4 COL	CNI	MC-130E, P-3C	335.00			R			-75			Nav/ILS
A6	51V4A COL	CNI	KC-135 A/D/E/Q/R	335.00			R			-75			Nav/ILS
A89	AN/ARN-108	CNI	A-10A, B-1B, F-16C/D, F-117A	335.00			R			-97.4			ILS/Localizer/Beacon/Vor
A90	AN/ARN-112(V)	CNI	F-15E	335.00			R			-87			Nav/ILS
A92	AN/ARN-127	CNI	C-5B, C-130H, MC-130H	335.00			R						Nav/Guidance
A95	AN/ARN-140	CNI	P-3C	335.00			R				20		ILS/Beacon/Vor
A102	AN/ARN-58A	CNI	F-111G	335.00			R			-87			Beacon/Nav/Radio Comm/ILS
A105	AN/ARN-67	CNI	B-52G	335.00			R			-76			Nav/Radio Comm/IS
A66	AN/ARC-143A	CNI	P-3C	399.95	0.1	0.1	C			-97			Radio Comm
A87	AN/ARC-51A	CNI	E-2C, CH-46D/E	399.95	0.02	0.02	C/R			-95			Radio Comm/Emerg/DF
A136	AN/UYQ-3A	CNI	KC-130T	399.95	0.065	0.065	C			-113	20		Comm
A68	AN/ARC-158	CNI	E-2C	399.97	0.174	0.174	C/R			-97.6	8		Comm/Atc/Data
A69	AN/ARC-159	CNI	A-6E, E-6A, EA-6B, UH-1N	399.97	0.04	0.04	C/R			-98			Radio Comm/Emerg/Secure Vox/Homing
A70	AN/ARC-159(V) 1	CNI	A-6E, EA-6B, KC-130T	399.97	0.04	0.04	C/R			-98			Radio Comm/Emerg/Secure Vox/Homing
A72	AN/ARC-164	CNI	A-10A, AC-130A/H, B-52G, C-5B, C-17A, C-130H, E-8A, F-15E, F-16C/D, F-111G, F-17A, KC-135/A/D/E/Q/R, MC-130E/H	399.97	0.01	0.01	C/R			-95	9		Radio Comm/Eccm
A73	AN/ARC-164(V) 1	CNI		399.97	0.1	0.1	C			-95	10		Radio Comm/Comm Other/DF/Data
A74	AN/ARC-164(V) 1	CNI		399.97	0.1	0.1	C			-95	10		Radio Comm/Comm Other/DF/Data
A77	AN/ARC-171(V)	CNI	B-1B, B-52G, E-3B/C	399.97	0.03	0.03	C/R			-103			Satellite
A80	AN/ARC-182(V)	CNI	AV-8B, E-2C, E-6A, EA-6B, F-14D, F/A-18C/D, P-3C, AH-1W, CH-46D/E, MH-53E, UH-1N, AV-8B	399.97		0.015	C/R			-112	5		Radio Comm/Emerg/Eccm/Homing/DF
A82	AN/ARC-187	CNI	AC-130A/H, C-17A, MC-130E/H, P-3C	399.97	0.4	0.4	C/R			-110	10		Comm/Secure Vox/Data
A132	AN/URC-108	CNI	AC-130A/H	399.97	0.1	0.1	C			-95	10		Satellite/Comm
A57	AN/ARA-25	CNI	AC-130A, KC-135A/D/E/Q/R, MC-130E	400.00			R						DF
A58	AN/ARA-25A	CNI	P-3C, CH-46D/E	400.00			R						DF
A84	AN/ARC-210(V)	CNI	B-1B, F/A-18C/D, UH-1N	400.00	0.015	0.015	C/R			-108			Comm/Data/Secure Vox/Freq Hop
A139	OA-8697AARD	CNI	A-10A, C-17A, F/A-18C/D, MC-130H, AH-1W, MH-53E	400.00			R			-73	6		DF
A124	AN/ARW-67	CNI	A-6E	420.00			R			-87			Guidance
A43	AN/APS-120	FC	E-2C	446.00									
A127	AN/ASQ-177(V) 1	CNI	UH-1N	450.00	0.125	0.125	C			-103			Data/Loc/Trck/Range/Nav/EW
A128	AN/ASQ-177(V) 2	CNI	CH-46E	450.00	0.125	0.125	C			-103			Data/Nav/EW/Loc/Trck/Range
A46	AN/APX-100(V) 1	CNI	AV-8B, E-2C, F-14D, AH-1W	1,090.00	0.5	0.000063	T/R	0.05	2500	-77	8		IFF/SFF/Rad/Trnspndr/Interogatr
A47	AN/APX-100(V) 2	CNI	AV-8B, C-17A	1,090.00	0.5	0.000063	T/R	0.05	2500	-77	8		IFF/SFF/Rad/Trnspndr
A48	AN/APX-101(V)	CNI	A-10A, B-1B, E-3B/C, E-8A, F-15E, F-16C/D, F-117A	1,090.00	1	0.000075	T/R	0.05	1500	-77			IFF/SFF

Table A-2. ECAC System Performance Data (Continued)

Reference Number	Nomenclature	Mission	Platform	Frequency (Mhz)	Peak Power (kW)	Average Power (kW)	Band Use	Pulse Width (usec)	Pulse Rate (pps)	Sensitivity (dBm)	Noise Figure (dB)	Doppler Phase Det. ?	System Function
A50	AN/APX-72	CNI	A-6E, AC-130 A/H, C-130H, E-2C, EA-6B, MC-130E, P-3C, S-3B, CH-46 D/E, MH-53E,UH-1N	1,090.00	0.5	0.00055	R/T	0.55	20000	-90			Atc/IFF/SFF/Location
A51	AN/APX-76A	CNI	E-2C, P-3C	1,090.00	2		T/R			-80	9		IFF/SFF
A52	AN/APX-76A(V)	CNI	P-3C, S-3B	1,090.00	2		T/R			-80	9		IFF/SFF
A53	AN/APX-76B	CNI	P-3C	1,090.00	1.5		T/R			-80	9		IFF/SFF
A54	AN/APX-76B(V)	CNI	KC-130T	1,090.00	1.5		T/R			-80	9		IFF/SFF
A55	AN/APX-76C(V)	CNI	F-14D	1,090.00	1.5		T/R			-83	9		Rdr/Tpdr/IFF/SFF
A88	AN/ARN-105	CNI	UH-1N	1,210.00	3	3	R/T						Nav/Tacan
A101	AN/ARN-52(V)	CNI	E-2C, P-3C	1,210.00	3	0.0016	R/T	3.5	150	-90			Tacan
A108	AN/ARN-84	CNI	A-6E, EA-6B(N)	1,210.00	4	0.00067	R/T	4	150	-90			Nav/Tacan
A109	AN/ARN-84(V) 1	CNI	P-3C, UH-1N	1,210.00	4	0.00048	R/T	4	30	-90			Nav/Tacan
A110	AN/ARN-84(V) 4	CNI	A-6E	1,210.00	4	0.00048	R/T	4	30	-90			Nav/Tacan
A111	AN/ARN-84(V) 5	CNI	S-3B	1,210.00	4	0.00048	R/T	4	30	-90			Nav/Tacan
A116	AN/ARN-90	CNI	KC-135Q	1,210.00	2.5	0.003	R/T	4	300	-90			Nav/Tacan
A97	AN/ARN-151(V) 1	CNI	C-17A, E-3B/C, E-8A	1,570.00			R						Gps-Navstr
A12	AN/APN-133	CNI	C-130H	1,660.00	0.08	0.000074	C	0.1	9830	-88	14		Altimeter
A129	AN/ASQ-T016	CNI	AV-8B, F/A-18C/D,	1,840.00	0.02	0.02	R/T						Comm/Data/Trainer
A18	AN/APN-169B	CNI	C-130H	3,600.00	2	0.0003	C	0.05	3000	-83	12		Nav
A19	AN/APN-171(V)	CNI	C-130H, E-2C, CH-46 D/E, MH-53E, UH-1N	4,300.00	0.3	0.00006	C	0.02	10000	-60			Altimeter
A14	AN/APN-141(V)	CNI	A-6E, EA-6B, P-3C	4,310.00	1	0.0003	C	0.105	3000	-65			Radar/Altimeter
A22	AN/APN-201	CNI	S-3B	4,320.00	0.00005	0.0000013	C	1	25000	-136			Alt
A28	AN/APN-224	CNI	A-10A, B-1B, B-52G	4,320.00	0.005	0.000024	C	0.21	23000	-85		yes	Doppler/Radar/Alt
A9	AL 101 COL	CNI	C-130H, E-3B/C, E-6A, KC-135 A/D/E/Q/R	4,350.00	0.0006	0.0006	C			-85			Altimeter/Cw
A126	AN/ASQ-141(V)	CNI	KC-135A/D/E/Q/R	4,350.00	0.0006	0.0006	C			-85			Altimeter/Cw
A31	AN/APN-232(V)	CNI	KC-130T	4,400.00	0.002	0.002	C			-130			Alt
A98	AN/ARN-152(V)	CNI	AC-130H, B-1B, C-130H, E-3B/C, MC-130E/H	5,090.00			R						Mls
A143	SST 171C MO	CNI	E-8A	5,900.00	0.3	0.000078	C	0.1	2600	-70			Beacon/Tracking
A125	AN/ASG-15	FC	B-52G	9,280.00	85	0.017	C	0.1	2000	-123			Fire Cntl
A44	AN/APS-133(V) 1	CNI	C-17A, E-3B/C, E-8A	9,310.00	65	0.065	T/R	5	200	-103	8		Rdr/Map/Beacon/Wther Avd
A45	AN/APS-133(V) 3	CNI	E-6A, EA-6B	9,310.00	65	0.065	C/R	5	200	-103	8		Beacon/Map/Rdr
A36	AN/APQ-150	CNI	AC-130H	9,380.00	5	0.0005	R/T	0.1	1060				Beacon/Search Rdr/Tracking
A33	AN/APN-59E(V)	CNI	AC-130 A/H, C-130H, KC-135 A/D/E/Q/R	9,410.00	70	0.06	C	4.5	180	-104			Beacon/Radar
A34	AN/APN-69	CNI	B-52G, KC-135 A/D/E/Q/R	9,410.00	5	0.023	R/T	0.6	7500	-66	12		Nav/Beacon
A49	AN/APX-105	CNI	B-1B, C-17A	9,500.00	0.3	0.00031	T/R	0.4	2600	-99			Rdr Tpdr
A144	SST 181X MO	CNI	AC-130A/H, MC-130E	9,500.00	0.55	0.0066	R/T	0.4	3000	-65	3		Beacon/Homing/Trck/Range/Bombing/Radar/Rdr Tpdr
A17	AN/APN-154(V)	CNI	A-6E, EA-6B, F-14D, AH-1W, CH-46 D/E, MH-53E	9,600.00	0.2	0.0004	T/R	0.75	2600	-65			Beacon/Nav
A40	AN/APS-115	FC	P-3C	9,600.00	143	0.143	C	2.5	400	-107	8		Search Rdr
A41	AN/APS-115A	FC	P-3C	9,600.00	143	0.143	C	2.5	400	-107	8		Search Rdr
A42	AN/APS-115B	FC	P-3C	9,600.00	143	0.143	C	2.5	400	-107			Search Rdr
A56	AN/APX-78	CNI	E-3B/C, F-111G, MC-130H	9,600.00	0.3	0.0003	T/R	0.4	2600	-99			Rdr Tpdr
A11	AN/ALQ-188	EW	F-16D	11,000.00	0.1	0.1	C						EW
A32	AN/APN-236	FC	F-111G	13,300.00	0.001	0.001	C			-138		yes	Radar/Doppler/Vel Meas

Table A-2. ECAC System Performance Data (Continued)

Reference Number	Nomenclature	Mission	Platform	Frequency (Mhz)	Peak Power (kW)	Average Power (kW)	Band Use	Pulse Width (usec)	Pulse Rate (pps)	Sensitivity (dBm)	Noise Figure (dB)	Doppler Phase Det. ?	System Function
A27	AN/APN-218	CNI	AC-130H, B-52G, C-130H, KC-135 A/D/E/Q/R	13,310.00	0.002	0.002	C			-138		yes	Nav/DFT Ang Ms/Doppler/Vel Meas
A20	AN/APN-187	CNI	P-3C	13,320.00		0.0003	C			-133		yes	Alt/Veloc Meas
A29	AN/APN-227	CNI	P-3C	13,320.00	0.00018	0.00018	C			-134			Nav
A16	AN/APN-153(V)	CNI	A-6E, E-2C, EA-6B	13,370.00	0.04	0.005	C	2.3	57,000	-88		yes	Nav/Veloc Meas/Doppler
A23	AN/APN-213	CNI	E-3B/C	13,380.00	0.0015	0.0015	C			-138		yes	Nav/DFT Ang Ms/Doppler/Veloc Meas
A15	AN/APN-147	CNI	C-130H	13,400.00		0.0005	C			-113		yes	Veloc Meas/DFT Ang/Ms/Doppler
A24	AN/APN-217(V)	CNI	CH-46E	13,400.00	0.0006	0.0006	C					yes	Nav/Doppler/Veloc Meas
A25	AN/APN-217(V) 3	CNI	UH-1N	13,400.00	0.0006	0.0006	C			-92		yes	Nav
A26	AN/APN-217A	CNI	MH-53E	13,400.00	0.0006	0.0006	C					yes	Nav/Doppler/Veloc Meas
A30	AN/APN-230	CNI	B-1B	13,450.00	0.002	0.002	C			-138			Nav
A21	AN/APN-200	CNI	S-3B	14,300.00		0.05	C			-126		yes	Nav/Vel Meas/DFT Ang Ms/Doppler
A10	AN/ALQ-176	EW	F-16D	15,500.00	1.2	1.2	T/C						Jammer
A59	AN/ARA-63	CNI	A-6E, AV-8B, E-2C, EA-6B, F-14D, F/A-18D, S-3B, AV-8B	15,680.00			R			-62	10		ILS/Mls/Nav
A13	AN/APN-134	CNI	KC-135A	16,280.00	2	0.07	C	1	36,000	-66			Nav/Radar
A37	AN/APQ-169	CNI	F-111G	16,400.00	3	0.08	C	13	2,002	-118	8		Radar/Mapping/Nav
A38	AN/APQ-170(V) 1	CNI	MC-130H	16,500.00	95	0.095	C	2.35	425	-101	6	yes	Ter Avoid/Ter Fl/Flr/Map/Wther Avd
A39	AN/APR-46A(V)	EW	AC-130H, MC-130E	18,000.00			R				18		EW/Intercept
A35	AN/APQ-122(V)	CNI	C-130H	33,400.00	60	0.024	C	0.1	4000	-90			Nav
A141	R-1623 APN	CNI	F/A-18C/D	33,400.00			R			-35			Nav
Navy Air													
S/M1	AN/APX-72	CNI	A-6E, AC-130 A/H, C-130H, E-2C, EA-6B, MC-130E, P-3C, S-3B, CH-46 D/E, MH-53E,UH-1N	1,090.00	0.5	0.00055	R/T	0.55	20000	-90			Atc/IFF/SFF/Location
S/M2	AN/ARC-182(V)	CNI	AV-8B, E-2C, E-6A, EA-6B, F-14D, F/A-18C/D, P-3C, AH-1W, CH-46D/E, MH-53E, UH-1N, AV-8B	399.97	0.015	0.015	C/R			-112	6		Radio Comm/Emerg/Eccm/Homing/DF
S/M3	OA-8697AARD	CNI	A-10A, C-17A, F/A-18C/D, MC-130H, AH-1W, MH-53E	400.00			R/C			-73	6		DF
S/M4	AN/ARC-201	CNI		87.97	0.05	0.05	C			-119	10		C Spd Spec/Secure Vox/Eccm/Freq Hop
S/M5	AN/BPS-15	CNI		9,600.00	35	0.026	C	0.5	1500	-96			Search Rdr/Nav/Trainger
S/M7	AN/PRC-119	CNI		87.97	0.004	0.004	C			-119	9		Radio Comm/Data/Eccm/Freq Hop/C Spd Spec
S/M8	AN/SPN-29B	CNI		0.10			R			-87			Loran
S/M19	AN/VRC-87	CNI		87.97	0.004	0.004	C			-119	9		Radio Comm/Data/Eccm/Freq Hop/C Spd Spec
S/M20	AN/VRC-89A	CNI		87.97			C						Radio Comm/Secure Vox/Eccm/Freq Hop/Cspd Spec
S/M21	AN/VRC-90	CNI		87.97	0.004	0.004	C			-119	9		Radio Comm/Data/Eccm/Freq Hop/C Spd Spec
S/M22	AN/VRC-90A	CNI		87.97	0.004	0.004	C			-119			Radio Comm/Secure Vox/Eccm/Freq Hop/C Spd Spec

Table A-2. ECAC System Performance Data (Continued)

Reference Number	Nomenclature	Mission	Platform	Frequency (Mhz)	Peak Power (kW)	Average Power (kW)	Band Use	Pulse Width (usec)	Pulse Rate (pps)	Sensitivity (dBm)	Noise Figure (dB)	Doppler Phase Det. ?	System Function
S/M23	AN/VRC-90C	CNI		87.97	0.004	0.004	C			-119			Comm/Secure Vox/Eccm/Freq Hop/C Spd Spec
S/M24	AN/VRC-91	CNI		87.97	0.004	0.004	C			-119	9		Radio Comm/Data/Eccm/Freq Hop/Cspd Spec
S/M25	AN/VRC-91A	CNI		87.97	0.004	0.004	C			-119			Radio Comm/Secure Vox/Eccm/Freq Hop/C Spd Spec
S/M26	AN/VRC-92	CNI		87.97	0.004	0.004	C			-119	9		Radio Comm/Data/Eccm/Freq Hop/C Spd Spec
S/M28	MARK 1 NRC	CNI		126.90	0.015	0.015	C/R			-98			Radio Comm/Beacon/Nav/Vor/ILS
S/M29	MARK 10 DEA	CNI		0.13	1.2	1.2	T						Test Range/Radio Comm
S/M30	MARK 10 NRC	CNI		135.95	0.008	0.008	R/C			-107			Radio Comm/Nav/ILS
S/M31	MARK 10 SPR	CNI		9,450.00	50	0.03	C	0.6	1000	-96	12		Nav/Search Rdr
S/M32	MARK 10 WIL	CNI		335.40	0.005	0.005	T						ILS
S/M33	MARK 12 NRC	CNI		135.90	0.01	0.01	R/C			-107			Radio Comm/Nav/Vor/ILS
S/M34	MARK 12 SPR	CNI		9,420.00	50	0.005	C	0.1	1000	-96	12		Nav
S/M35	MARK 12 WIL	CNI		75.00	0.00075	0.00075	T						Beacon
S/M36	MARK 13 MOD	FC		8,890.00	50	0.024	C	0.3	1620	-91	15		Fire Cntl
S/M37	MARK 26 MOD	FC		3,100.00	30	0.081	C	0.5	540	-103	10		Trck/Range/Fire Cntl
Marine Ground													
S/M6	AN/PPS-15	FC		10,400.00	0.025	0.000094	C	0.1	37500	-116	12	yes	Fire Cntl/Radar/Search Rdr/Doppler
S/M16	AN/TSQ-129			450.00	0.125	0.125	C			-144	4		Data/Loc/Trck/Range/Nav/EW
S/M13	AN/TSC-85B(V)1	CNI		8,400.00	0.5	0.5	D/U			-126	1.9		Satellite/Comm/Radio Comm/Secure Vox/Data
S/M15	AN/TSC-120	CNI		29.99	1	1	M			-110	13		Radio Comm/Data
S/M14	AN/TSC-85B02	CNI		8,400.00	0.5	0.5	R/T			-126			Satellite
S/M12	AN/TPS-59	FC		1,400.00	45	0.024	C	2	272	-98			Radar/Pulse Comp/Atc
Navy Ships													
S/M9	AN/SPS-40	FC, Radar		450.00	200	3.6	C	60	300	-110	6		Search Rdr
S/M10	AN/SPS-49	FC, Radar		942.00	280	9.5	C	125	270	-112	4		Radar/Freq Hop/Pulse Comp/Search RCI
S/M11	AN/SQQ-89(V) T	Sonar		173.50	0.000001	0.000001	T						Sònobuoy/Trainer
S/M18	AN/URN-25	CNI TACAN		1,150.00	3	3	T/R			-92			Tacan
S/M17	AN/UPX-27	CNI IFF Set		1,090.00	2	0.00042	T/R	0.7	300	-84			Interogatr/IFF/SFF
S/M27	AN/WRR-7	CNI Radio		0.06			R			-124			Radio Comm

APPENDIX B

COST MODEL

This appendix briefly describes the model for estimating the 10-year costs of the improvements. IDA developed the model in the previous IDA study of CASS (Reference 1), where it is explained more fully.

The 10-year cost of an improvement is the sum of the non-recurring costs for development plus a unit procurement cost multiplied by a nominal 100 systems, and the recurring yearly support cost multiplied by 10, the number of years in the costing horizon:

10-Year Cost = Development + (Unit Procurement × 100) + (Yearly Support × 10)

The non-recurring and recurring costs are calculated by the equations shown below. Note that all three of the terms in the equations are based on modifications of the commercial development cost (the costs the private firm paid to develop the upgrade), and the commercial price (the cost that the private firm would charge the Navy for buying the commercial version of the item). The numerical values of the modifications (explained below) were derived in Reference 1, and are detailed in that report. These factors were all obtained from planning factors obtained from Lockheed Martin, the CASS developer, and from people at the Patuxent Naval Air Station who have been involved with estimating CASS support costs.

Development Cost = (Commercial Development Cost × Technology Factor)
+ Integration Cost + (Integration Profit/G&A)

Unit Procurement Cost = (Commercial Price × Technology Factor × Ruggedization Factor
× Quantity Discount) + Interface Cost + (Interface Profit/G&A)
+ DoD Support Investment

Yearly Support Cost = 10% × [(Commercial Price × Technology Factor × Ruggedization Factor
× Quantity Factor) + Interface Cost + (Interface Profit/G&A)]

1. The first modification of the non-recurring cost is a multiplicative Technology Factor (0.988 and 0.75 per year for non-computer and computer items, respectively) to anticipate the reduction in price, given current trends in prices of computers and other electronics between today and the time we assume

that the upgrade would be purchased. To this product is added the Integration expenses for inserting the upgrade into the CASS station (100 times the Interface factor described below), and a rate for Integration Profit and G&A (General and Administrative; 15 percent of the Integration cost).

2. The modifications for the unit procurement cost are more complicated. The Commercial Price is first modified by the Technology Factor, a Ruggedization Factor (2) to modify the commercial product for a military application, and a Quantity Discount (0.85) to estimate the reduction that DoD would receive, given a purchase of 100 or more versions of the upgrade. The resulting product, which is an estimate of the final price to Lockheed Martin, is increased by an Interface Cost (a procurement cost similar to integration; 20 percent of the final Lockheed Martin price), Interface Profit and G&A (15 percent of the sum of the final Lockheed Martin price and the Interface cost), and finally a DoD cost for support items such as spares (26 percent of the sum of the Lockheed Martin price, the Interface Cost, and the Interface Profit/G&A Cost).

3. The yearly support cost is estimated by a percentage (10 percent) of the sum of the final Lockheed Martin price, the Interface Cost, and the Interface Profit/G&A.

APPENDIX C

DOWNSIZE CASS TESTERS

The current CASS configurations (Hybrid, RF, CNI, and EO) are 5- and 6-bay systems whose size limits their installation to aircraft carriers (CVs), amphibious ships, shore-based Aircraft Intermediate Maintenance Departments (AIMDs), Marine Corps Marine Aviation Logistics Squardon (MALS) and 4th Echelon maintenance facilities, and depots and factories. This section explores the design of a CASS downsize tester, one or two bays in size, that could be installed on smaller Navy combatants (cruisers, destroyers, frigates, and submarines), Navy support ships (underway replenishment ships and tenders), and with deployed Marine Corps ground units. Depots and factories could also use downsize units for applications that do not require a full-size CASS. The problems of software compatibility between Test Program Sets for current and downsize testers is addressed in Part II of this study.

Table C-1 lists the potential sites for a full-size CASS, a downsize CASS, and a man-portable and reconfigurable CASS.

A man-portable and reconfigurable CASS would offer the ability to test electronics in the field, thus speeding up the return of weapons to service and reducing spares and other maintenance resources. Several applications for such testers have been suggested, including a CASS version of the Marine Corps Third Echelon Test Set (TETS), and configurations of CASS that could be installed aboard the MV-22 aircraft or a HMMWV. (The HMMWV would need to carry or tow a generator for power.)

TETS is projected to weigh 400 pounds, occupy 30 cubic feet, and be man-portable. The MV-22 maintenance concept calls for the aircraft to be deployed with a tester stowed in its limited internal cargo space. The tester would have to fit on an L10 pallet, be no more than 4 feet high, and be able to be lifted by two men. Such testers should be capable of testing multi-function radar, advanced tactical jammers, and advanced tactical IR countermeasures.

These applications might possibly be achieved by constructing a downsize CASS system consisting of a minimum core to which could be added the specific instruments needed for the systems being supported. The core would contain the central processor, associated computer storage and display units, high-usage test resources such as UUT

power supplies, a digital multimeter, and a DTU. The current buss architecture of the CASS system could readily support this concept, but the station software would require significant modification (see Part II).

Table C-1. Potential Sites for CASS

	Potential Sites for Different Versions of CASS		
Equipment for Test	Full	Downsize	Man-portable
Navy aircraft	Aircraft carriers Amphibious ships AIMDs SIMAs Depots Factories		
Navy ships	Aircraft carriers Amphibious ships Shipyards	Escort ships Submarines Tenders UnRep ships	
Marine aircraft	MALS Amphibious ships		MV-22
Marine ground units	4th Echelon		TETS
	Depot Factory		HMMWV

Table C-2 defines several downsize CASS designs (CASS I, II, and III) by listing the changes with respect to the current, full-size CASS. The changes are cumulative: the CASS II changes, for example, are in addition to the CASS I changes.

Table C-3 shows the results of a brief effort to estimate the size and weight reductions that could be achieved with a CASS that retains a basic core capability. The CASS III configuration still contains significant RF, digital, and analog test capability, and has a weight and size that would allow it to be installed in a 1- or 2-bay configuration.

The CASS I, II, and III downsize units contain 3.8, 2.4, and 1.6 equivalent racks, respectively. (The number of "equivalent racks" was obtained by dividing the total volume of instruments and other components by the volume of a full-size CASS rack, which has dimensions 72 inches by 34 inches by 26 inches. We used the term "equivalent" because we did not conduct a complete space analysis to determine how the instruments would fit together.) CASS III is small enough to meet several of the possible applications cited in Table C-1. There is some uncertainty concerning the best number of pins, given the

tradeoff between test capability, size, weight, and cost. The 96 pins listed for CASS III may be too few, and 192 pins might be the better choice.

Table C-2. Definition of Hypothetical Downsize CASS Designs

CASS I Changes
- Removal of most power conditioning equipment
- Fewer asset controllers
- Fewer UUT power supplies
- Fewer interfaces
- No special modulators
- Fewer AWGs
- No spectrum analyzer

CASS II Changes
- Re-configured computer and DTU (50 percent reduction in size and weight), following the two recent Value Engineering Change Proposals (VECPs)
- Replacement of two RF synthesizers with new, smaller designs (50 percent reduction in size)

CASS III Changes
- Reduction of DTU from 336 to 96 pins

Table C-3. CASS Downsize Potential

	Full CASS[a]	CASS I	CASS II	CASS III
Weight (Pounds)	5,370	2270	1710	1370
Size (Cubic Feet)	221	140	90	60
DTU Pins		336	336	96
Racks	6.0	3.8	2.4	1.6

[a] Weight and size for RF CASS based on prime item specification of August 1992.

Even this brief analysis, however, suggests that CASS has the potential to be down-sized to a 1- or 2-bay configuration while still retaining much of its capability.

REFERENCE

REFERENCE

[1] Levine, Daniel B. Levine, Waynard C. Devers, Bernard L. Retterer, Howard Savage, Clayton V. Stewart, and Daniel M. Utech, "The Costs and Benefits of Pre-Planned Product Improvements for the Consolidated Automated Support System (CASS)," Institute for Defense Analyses, Paper P-2848, November 1993.

ABBREVIATIONS

ABBREVIATIONS

ABBET	A Broad-Based Environment for Test
ADS	Adaptive Diagnostic System
AIESTATE	Artificial Intelligence and Expert System Tie to ATE
AIMD	Aircraft Intermediate Maintenance Departments
ATE	Automatic Test Equipment
ATI	Automated Technical Information
ATLAS	A Test Language for All Systems
ATPG	Automatic Test Program Generation
ATS	Automatic Test System
AWG	Arbitrary Waveform Generator
BIC	Bookkeeping and Instrument Communication
CASS	Consolidated Automated Support System
CEC	Cooperative Engagement Capability
CIP	CASS Implementation Plan
CNI	Communication, Navigation, Identification
COEA	Cost and Operational Effectiveness Analysis
COTS	Commercial Off-The-Shelf
CPU	Central Processing Unit
CV	aircraft carriers
dBc	Number of decibels relative to the carrier frequency
dBm	Number of decibels relative to a 1 milliwatt (10^{-3}) standard
DGAR	Designated Government Acceptance Representative
DICON	Development Icon
DMM	Digital Multimeter
DTIF	Digital Test Interface Format
DTU	Digital Test Unit
EA	Executive Agent

ECAC	Electromagnetic Compatibility Analysis Center
ECP	Engineering Change Proposal
EMI	Electromagnetic Interference
EO	Electro-Optical
EOSS	Eletro-Optics Subsystem
ESQA	Expert System Quality Analyzer
FDL	Fault Dictionary Language
FEP	Functional Extension Program
G&A	General and Administrative
GHz	Gigahertz (10^9 Hertz, or cycles per second)
GPETE	General Purpose Electronic Test Equipment
HMMWV	High Mobility Multipurpose Wheeled Vehicle
HP	Hewlett Packard
HPDT	High Power Device Tester
Hz	Hertz, or cycles per second
ID	Interface Device
IDA	Institute for Defense Analyses
IDSS	Integrated Diagnostic Support System
IEEE	Institute of Electrical and Electronic Engineers
IFTE	Integrated Family of Test Equipment
IMOM	Intermediate Maintenance Operations Management System
MALS	Marine Aviation Logistics Squadron
Mbs	Million bits per second
MHz	Megahertz (10^6 Hertz, or cycles per second)
MMS	Modular Measurement System
MTA	Microwave Transition Amplifier
NAS	Naval Air Station
NAVAIR	Naval Air Systems Command
NAVSEA	Naval Sea Systems Command
NAWC	Naval Air Warfare Center
NS	Nanosecond (10^{-9} seconds)
NUWC	Naval Undersea Warfare Center

OSD	Office of Secretary of Defense
PDR	Preliminary Design Review
PMA	Program Manager, NAVAIR
PS	Picosecond (10^{-12} seconds)
RDL	Resource Description Language
RF	Radio Frequency
SMATS	Self Maintenance and Test System
SRA	System Replaceable Assembly
SSM	System Synthesis Model
TEDL	Test Equipment Description Language
TETS	Third Echelon Test Set
TMIMS	Test and Maintenance Information Management Standard
TPS	Test Program Set
TRSL	Test Requirements Specification Language
TWG	TPS Working Group
UUT	Unit Under Test
VAST	Versatile Avionics System Test
VECP	Value Engineering Change Proposals
WBS	Work Breakdown Structure
WRA	Weapon Replaceable Assembly
WSTA	Weapon System Testability Analyzer

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	April 1996	Final Report, Jan 1994–Apr 1996

4. TITLE AND SUBTITLE

The Capability of the Consolidated Automated Support System (CASS) to Meet Expanded Test Requirements

5. FUNDING NUMBERS

DASW01 94 C 0054

T-AO7-1095

6. AUTHOR(S)

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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

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1801 N. Beauregard Street
Alexandria, VA 22311-1772

8. PERFORMING ORGANIZATION REPORT NUMBER

IDA Paper P-3131

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

OASD (P&L)
Room 2B322, The Pentagon
Washington, DC 20301

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12A. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

12B. DISTRIBUTION CODE

13. ABSTRACT ***(Maximum 200 words)***

This study is an extension of previous IDA work (Paper P-2848) on improvements to the Consolidated Automated Support System (CASS). Part 1 of the current study identifies improvements to increase the coverage of CASS to include not only Navy avionics, for which the system was originally designed, but also the electronics of Navy ships, Marine Corps aircraft, and Marine Corps ground systems. Part 2 identifies software improvements to increase compatibility among different versions of CASS, to improve the general operability of the system, and to meet current DoD mandates that require commercial standards for electronics.

14. SUBJECT TERMS

Consolidated Automated Support System (CASS); Electronic Equipment; Automatic Test Systems (ATS); Military Equipment

15. NUMBER OF PAGES

153

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	SAR

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

UNCLASSIFIED